

```
In [ ]: # This mounts your Google Drive to the Colab VM.
from google.colab import drive
drive.mount('/content/drive')

# TODO: Enter the foldername in your Drive where you have saved the unzipped
# assignment folder, e.g. 'cs6353/assignments/assignment2/'
FOLDERNAME = 'CS6353/Assignments/assignment2/assignment2/'
assert FOLDERNAME is not None, "[!] Enter the foldername."

# Now that we've mounted your Drive, this ensures that
# the Python interpreter of the Colab VM can load
# python files from within it.
import sys
sys.path.append('/content/drive/My Drive/{}'.format(FOLDERNAME))

# This downloads the CIFAR-10 dataset to your Drive
# if it doesn't already exist.
%cd /content/drive/My\ Drive/$FOLDERNAME/cs6353/datasets/
!bash get_datasets.sh
%cd /content/drive/My\ Drive/$FOLDERNAME

# Install requirements from colab_requirements.txt
# TODO: Please change your path below to the colab_requirements.txt file
! python -m pip install -r /content/drive/My\ Drive/$FOLDERNAME/colab_requirements.txt
```

Mounted at /content/drive  
/content/drive/My Drive/CS6353/Assignments/assignment2/assignment2/cs6353/datasets  
--2024-09-30 00:42:53-- http://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz  
Resolving www.cs.toronto.edu (www.cs.toronto.edu)... 128.100.3.30  
Connecting to www.cs.toronto.edu (www.cs.toronto.edu)|128.100.3.30|:80... connected.  
HTTP request sent, awaiting response... 200 OK  
Length: 170498071 (163M) [application/x-gzip]  
Saving to: 'cifar-10-python.tar.gz'

cifar-10-python.tar 100%[=====>] 162.60M 51.8MB/s in 3.3s

2024-09-30 00:42:57 (49.8 MB/s) - 'cifar-10-python.tar.gz' saved [170498071/170498071]

cifar-10-batches-py/  
cifar-10-batches-py/data\_batch\_4  
cifar-10-batches-py/readme.html  
cifar-10-batches-py/test\_batch  
cifar-10-batches-py/data\_batch\_3  
cifar-10-batches-py/batches.meta  
cifar-10-batches-py/data\_batch\_2  
cifar-10-batches-py/data\_batch\_5  
cifar-10-batches-py/data\_batch\_1  
/content/drive/My Drive/CS6353/Assignments/assignment2/assignment2  
Requirement already satisfied: anyio==3.7.1 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 1)) (3.7.1)  
Collecting appnope==0.1.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 2))  
Downloading appnope-0.1.3-py2.py3-none-any.whl.metadata (1.2 kB)  
Requirement already satisfied: argon2-cffi==23.1.0 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 3)) (23.1.0)  
Requirement already satisfied: argon2-cffi-bindings==21.2.0 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 4)) (21.2.0)  
Collecting arrow==1.2.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 5))  
Downloading arrow-1.2.3-py3-none-any.whl.metadata (6.9 kB)  
Collecting asttokens==2.2.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 6))  
Downloading asttokens-2.2.1-py2.py3-none-any.whl.metadata (4.8 kB)  
Collecting async-lru==2.0.4 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 7))  
Downloading async-lru-2.0.4-py3-none-any.whl.metadata (4.5 kB)  
Collecting attrs==23.1.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 8))  
Downloading attrs-23.1.0-py3-none-any.whl.metadata (11 kB)  
Collecting Babel==2.12.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 9))  
Downloading Babel-2.12.1-py3-none-any.whl.metadata (1.3 kB)  
Requirement already satisfied: backcall==0.2.0 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 10)) (0.2.0)  
Collecting beautifulsoup4==4.12.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 11))  
Downloading beautifulsoup4-4.12.2-py3-none-any.whl.metadata (3.6 kB)  
Collecting bleach==6.0.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 12))  
Downloading bleach-6.0.0-py3-none-any.whl.metadata (29 kB)

Collecting certifi==2023.7.22 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 13))  
 Downloading certifi-2023.7.22-py3-none-any.whl.metadata (2.2 kB)  
 Collecting cffi==1.15.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 14))  
 Downloading cffi-1.15.1-cp310-cp310-manylinux\_2\_17\_x86\_64.manylinux2014\_x86\_64.whl.metadata (1.1 kB)  
 Collecting charset-normalizer==3.2.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 15))  
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 Collecting comm==0.1.4 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 16))  
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 Collecting contourpy==1.1.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 17))  
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 Collecting cycler==0.11.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 18))  
 Downloading cycler-0.11.0-py3-none-any.whl.metadata (785 bytes)  
 Collecting debugpy==1.6.7.post1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 19))  
 Downloading debugpy-1.6.7.post1-cp310-cp310-manylinux\_2\_17\_x86\_64.manylinux2014\_x86\_64.whl.metadata (1.1 kB)  
 Requirement already satisfied: decorator<=5.0 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 20)) (4.4.2)  
 Requirement already satisfied: defusedxml==0.7.1 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 21)) (0.7.1)  
 Collecting executing==1.2.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 22))  
 Downloading executing-1.2.0-py2.py3-none-any.whl.metadata (8.9 kB)  
 Collecting fastjsonschema==2.18.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 23))  
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 Collecting fonttools==4.42.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 24))  
 Downloading fonttools-4.42.1-cp310-cp310-manylinux\_2\_17\_x86\_64.manylinux2014\_x86\_64.whl.metadata (150 kB)  


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 151.0/151.0 kB 4.9 MB/s eta 0:00:00  
 Collecting fqdn==1.5.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 25))  
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 Collecting idna==3.4 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 26))  
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 Collecting imageio==2.31.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 27))  
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 Requirement already satisfied: ipykernel<=5.5.6 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 28)) (5.5.6)  
 Requirement already satisfied: ipython<=7.34.0 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 29)) (7.34.0)  
 Collecting isoduration==20.11.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 30))  
 Downloading isoduration-20.11.0-py3-none-any.whl.metadata (5.7 kB)

Collecting jedi==0.19.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 31))  
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Collecting Jinja2==3.1.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 32))  
 Downloading Jinja2-3.1.2-py3-none-any.whl.metadata (3.5 kB)  
Collecting json5==0.9.14 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 33))  
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Collecting jsonpointer==2.4 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 34))  
 Downloading jsonpointer-2.4-py2.py3-none-any.whl.metadata (2.5 kB)  
Collecting jsonschema==4.19.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 35))  
 Downloading jsonschema-4.19.0-py3-none-any.whl.metadata (8.2 kB)  
Collecting jsonschema-specifications==2023.7.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 36))  
 Downloading jsonschema\_specifications-2023.7.1-py3-none-any.whl.metadata (2.8 kB)  
Collecting jupyter-events==0.7.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 37))  
 Downloading jupyter\_events-0.7.0-py3-none-any.whl.metadata (5.5 kB)  
Collecting jupyter-lsp==2.2.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 38))  
 Downloading jupyter\_lsp-2.2.0-py3-none-any.whl.metadata (1.8 kB)  
Requirement already satisfied: jupyter\_client<8.0 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 39)) (6.1.12)  
Collecting jupyter\_core==5.3.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 40))  
 Downloading jupyter\_core-5.3.1-py3-none-any.whl.metadata (3.4 kB)  
Collecting jupyter\_server==2.7.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 41))  
 Downloading jupyter\_server-2.7.2-py3-none-any.whl.metadata (8.6 kB)  
Collecting jupyter\_server\_terminals==0.4.4 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 42))  
 Downloading jupyter\_server\_terminals-0.4.4-py3-none-any.whl.metadata (6.3 kB)  
Collecting jupyterlab==4.0.5 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 43))  
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Collecting jupyterlab-pygments==0.2.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 44))  
 Downloading jupyterlab\_pygments-0.2.2-py2.py3-none-any.whl.metadata (1.9 kB)  
Collecting jupyterlab\_server==2.24.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 45))  
 Downloading jupyterlab\_server-2.24.0-py3-none-any.whl.metadata (5.8 kB)  
Collecting kiwisolver==1.4.5 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 46))  
 Downloading kiwisolver-1.4.5-cp310-cp310-manylinux\_2\_12\_x86\_64.manylinux2010\_x86\_64.whl.metadata (6.4 kB)  
Collecting MarkupSafe==2.1.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 47))  
 Downloading MarkupSafe-2.1.3-cp310-cp310-manylinux\_2\_17\_x86\_64.manylinux2014\_x86\_64.whl.metadata (3.0 kB)  
Collecting matplotlib==3.7.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 48))  
 Downloading matplotlib-3.7.2-cp310-cp310-manylinux\_2\_17\_x86\_64.manylinux2014\_x86\_64.whl.metadata (5.6 kB)  
Collecting matplotlib-inline==0.1.6 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 49))  
 Downloading matplotlib\_inline-0.1.6-py3-none-any.whl.metadata (2.8 kB)

Collecting mistune==3.0.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 50))  
 Downloading mistune-3.0.1-py3-none-any.whl.metadata (1.7 kB)  
 Collecting nbclient==0.8.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 51))  
 Downloading nbclient-0.8.0-py3-none-any.whl.metadata (7.8 kB)  
 Collecting nbconvert==7.7.4 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 52))  
 Downloading nbconvert-7.7.4-py3-none-any.whl.metadata (8.0 kB)  
 Collecting nbformat==5.9.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 53))  
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 Collecting nest-asyncio==1.5.7 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 54))  
 Downloading nest\_asyncio-1.5.7-py3-none-any.whl.metadata (2.7 kB)  
 Collecting notebook\_shim==0.2.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 55))  
 Downloading notebook\_shim-0.2.3-py3-none-any.whl.metadata (4.0 kB)  
 Collecting numpy<1.24,>=1.22 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 56))  
 Downloading numpy-1.23.5-cp310-cp310-manylinux\_2\_17\_x86\_64.manylinux2014\_x86\_64.whl.metadata (2.3 kB)  
 Collecting overrides==7.4.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 57))  
 Downloading overrides-7.4.0-py3-none-any.whl.metadata (5.7 kB)  
 Collecting packaging==23.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 58))  
 Downloading packaging-23.1-py3-none-any.whl.metadata (3.1 kB)  
 Collecting pandas<=1.5.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 59))  
 Downloading pandas-1.5.3-cp310-cp310-manylinux\_2\_17\_x86\_64.manylinux2014\_x86\_64.whl.metadata (11 kB)  
 Collecting pandocfilters==1.5.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 60))  
 Downloading pandocfilters-1.5.0-py2.py3-none-any.whl.metadata (9.0 kB)  
 Collecting parso==0.8.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 61))  
 Downloading parso-0.8.3-py2.py3-none-any.whl.metadata (7.5 kB)  
 Collecting pexpect==4.8.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 62))  
 Downloading pexpect-4.8.0-py2.py3-none-any.whl.metadata (2.2 kB)  
 Requirement already satisfied: pickleshare==0.7.5 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 63)) (0.7.5)  
 Collecting Pillow==10.0.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 64))  
 Downloading Pillow-10.0.0-cp310-cp310-manylinux\_2\_28\_x86\_64.whl.metadata (9.5 kB)  
 Collecting platformdirs==3.10.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 65))  
 Downloading platformdirs-3.10.0-py3-none-any.whl.metadata (11 kB)  
 Collecting prometheus-client==0.17.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 66))  
 Downloading prometheus\_client-0.17.1-py3-none-any.whl.metadata (24 kB)  
 Collecting prompt-toolkit==3.0.39 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 67))  
 Downloading prompt\_toolkit-3.0.39-py3-none-any.whl.metadata (6.4 kB)  
 Requirement already satisfied: psutil==5.9.5 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 68)) (5.9.5)  
 Requirement already satisfied: ptyprocess==0.7.0 in /usr/local/lib/python3.10/dist-pa

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ckages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 69)) (0.7.0)
Collecting pure-eval==0.2.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 70))
  Downloading pure_eval-0.2.2-py3-none-any.whl.metadata (6.2 kB)
Collecting pycparser==2.21 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 71))
  Downloading pycparser-2.21-py2.py3-none-any.whl.metadata (1.1 kB)
Collecting Pygments==2.16.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 72))
  Downloading Pygments-2.16.1-py3-none-any.whl.metadata (2.5 kB)
Collecting pyparsing==3.0.9 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 73))
  Downloading pyparsing-3.0.9-py3-none-any.whl.metadata (4.2 kB)
Requirement already satisfied: python-dateutil==2.8.2 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 74)) (2.8.2)
Collecting python-json-logger==2.0.7 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 75))
  Downloading python_json_logger-2.0.7-py3-none-any.whl.metadata (6.5 kB)
Collecting pytz==2023.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 76))
  Downloading pytz-2023.3-py2.py3-none-any.whl.metadata (22 kB)
Collecting PyYAML==6.0.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 77))
  Downloading PyYAML-6.0.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl.metadata (2.1 kB)
Requirement already satisfied: pyzmq<25 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 78)) (24.0.1)
Collecting referencing==0.30.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 79))
  Downloading referencing-0.30.2-py3-none-any.whl.metadata (2.6 kB)
Collecting requests==2.31.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 80))
  Downloading requests-2.31.0-py3-none-any.whl.metadata (4.6 kB)
Collecting rfc3339-validator==0.1.4 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 81))
  Downloading rfc3339_validator-0.1.4-py2.py3-none-any.whl.metadata (1.5 kB)
Collecting rfc3986-validator==0.1.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 82))
  Downloading rfc3986_validator-0.1.1-py2.py3-none-any.whl.metadata (1.7 kB)
Collecting rpds-py==0.9.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 83))
  Downloading rpds_py-0.9.2-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl.metadata (3.7 kB)
Collecting scipy==1.11.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 84))
  Downloading scipy-1.11.2-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl.metadata (59 kB)
  59.1/59.1 kB 3.1 MB/s eta 0:00:00
Collecting seaborn==0.12.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 85))
  Downloading seaborn-0.12.2-py3-none-any.whl.metadata (5.4 kB)
Collecting Send2Trash==1.8.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 86))
  Downloading Send2Trash-1.8.2-py3-none-any.whl.metadata (4.0 kB)
Requirement already satisfied: six==1.16.0 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requirements.txt (line 87)) (1.16.0)

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Collecting sniffio==1.3.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 88))  
 Downloading sniffio-1.3.0-py3-none-any.whl.metadata (3.6 kB)  
 Collecting soupsieve==2.4.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 89))  
 Downloading soupsieve-2.4.1-py3-none-any.whl.metadata (4.7 kB)  
 Collecting stack-data==0.6.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 90))  
 Downloading stack\_data-0.6.2-py3-none-any.whl.metadata (18 kB)  
 Collecting terminado==0.17.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 91))  
 Downloading terminado-0.17.1-py3-none-any.whl.metadata (5.9 kB)  
 Collecting tinycss2==1.2.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 92))  
 Downloading tinycss2-1.2.1-py3-none-any.whl.metadata (3.0 kB)  
 Collecting tornado<=6.3.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 93))  
 Downloading tornado-6.3.2-cp38-abi3-manylinux\_2\_5\_x86\_64.manylinux1\_x86\_64.manylinux\_2\_17\_x86\_64.manylinux2014\_x86\_64.whl.metadata (2.5 kB)  
 Collecting traitlets==5.9.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 94))  
 Downloading traitlets-5.9.0-py3-none-any.whl.metadata (10 kB)  
 Collecting tzdata==2023.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 95))  
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 Collecting uri-template==1.3.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 96))  
 Downloading uri\_template-1.3.0-py3-none-any.whl.metadata (8.8 kB)  
 Collecting urllib3==2.0.4 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 97))  
 Downloading urllib3-2.0.4-py3-none-any.whl.metadata (6.6 kB)  
 Collecting wcwidth==0.2.6 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 98))  
 Downloading wcwidth-0.2.6-py2.py3-none-any.whl.metadata (11 kB)  
 Collecting webcolors==1.13 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 99))  
 Downloading webcolors-1.13-py3-none-any.whl.metadata (2.6 kB)  
 Requirement already satisfied: webencodings==0.5.1 in /usr/local/lib/python3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 100)) (0.5.1)  
 Collecting websocket-client==1.6.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 101))  
 Downloading websocket\_client-1.6.2-py3-none-any.whl.metadata (7.5 kB)  
 Requirement already satisfied: exceptiongroup in /usr/local/lib/python3.10/dist-packages (from anyio==3.7.1->-r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 1)) (1.2.2)  
 Requirement already satisfied: typing-extensions>=4.0.0 in /usr/local/lib/python3.10/dist-packages (from async-lru==2.0.4->-r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 7)) (4.12.2)  
 Collecting jupyter\_client<8.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 39))  
 Downloading jupyter\_client-7.4.9-py3-none-any.whl.metadata (8.5 kB)  
 Requirement already satisfied: tomli in /usr/local/lib/python3.10/dist-packages (from jupyterlab==4.0.5->-r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 43)) (2.0.1)  
 Requirement already satisfied: ipython-genutils in /usr/local/lib/python3.10/dist-packages (from ipykernel<=5.5.6->-r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab\_requirements.txt (line 28)) (0.2.0)  
 Requirement already satisfied: setuptools>=18.5 in /usr/local/lib/python3.10/dist-packages (from ipython<=7.34.0->-r /content/drive/My Drive/CS6353/Assignments/assignment



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2/assignment2//colab_requirements.txt (line 29)) (71.0.4)
Requirement already satisfied: entrypoints in /usr/local/lib/python3.10/dist-packages
(from jupyter_client<8.0->-r /content/drive/My Drive/CS6353/Assignments/assignment2/a
ssignment2//colab_requirements.txt (line 39)) (0.4)
Downloading appnope-0.1.3-py2.py3-none-any.whl (4.4 kB)
Downloading arrow-1.2.3-py3-none-any.whl (66 kB)
_____ 66.4/66.4 kB 4.7 MB/s eta 0:00:00
Downloading asttokens-2.2.1-py2.py3-none-any.whl (26 kB)
Downloading async_lru-2.0.4-py3-none-any.whl (6.1 kB)
Downloading attrs-23.1.0-py3-none-any.whl (61 kB)
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Downloading Babel-2.12.1-py3-none-any.whl (10.1 MB)
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Downloading cffi-1.15.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (4
41 kB)
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x86_64.whl (201 kB)
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Downloading comm-0.1.4-py3-none-any.whl (6.6 kB)
Downloading contourpy-1.1.0-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l (300 kB)
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Downloading debugpy-1.6.7.post1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_6
4.whl (3.0 MB)
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Downloading fastjsonschema-2.18.0-py3-none-any.whl (23 kB)
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hl (4.5 MB)
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Downloading jupyter_lsp-2.2.0-py3-none-any.whl (65 kB)
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Downloading jupyter_server-2.7.2-py3-none-any.whl (375 kB)
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Downloading jupyter_server_terminals-0.4.4-py3-none-any.whl (13 kB)
Downloading jupyterlab-4.0.5-py3-none-any.whl (9.2 MB)
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Downloading jupyterlab_pygments-0.2.2-py2.py3-none-any.whl (21 kB)
Downloading jupyterlab_server-2.24.0-py3-none-any.whl (57 kB)
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hl (1.6 MB)
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hl (11.6 MB)
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Downloading overrides-7.4.0-py3-none-any.whl (17 kB)
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Downloading Pillow-10.0.0-cp310-cp310-manylinux_2_28_x86_64.whl (3.4 MB)
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Downloading prompt_toolkit-3.0.39-py3-none-any.whl (385 kB)
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Downloading pure_eval-0.2.2-py3-none-any.whl (11 kB)
Downloading pycparser-2.21-py2.py3-none-any.whl (118 kB)
_____ 118.7/118.7 kB 8.5 MB/s eta 0:00:00
Downloading Pygments-2.16.1-py3-none-any.whl (1.2 MB)
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Downloading rfc3986_validator-0.1.1-py2.py3-none-any.whl (4.2 kB)
Downloading rpds_py-0.9.2-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl
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Downloading Send2Trash-1.8.2-py3-none-any.whl (18 kB)
Downloading sniffio-1.3.0-py3-none-any.whl (10 kB)
Downloading soupsieve-2.4.1-py3-none-any.whl (36 kB)
Downloading stack_data-0.6.2-py3-none-any.whl (24 kB)
Downloading terminado-0.17.1-py3-none-any.whl (17 kB)
Downloading tinycss2-1.2.1-py3-none-any.whl (21 kB)
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117.4/117.4 kB 10.7 MB/s eta 0:00:00
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341.8/341.8 kB 23.5 MB/s eta 0:00:00
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123.9/123.9 kB 8.9 MB/s eta 0:00:00
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57.0/57.0 kB 4.3 MB/s eta 0:00:00
Downloading jupyter_client-7.4.9-py3-none-any.whl (133 kB)
133.5/133.5 kB 12.5 MB/s eta 0:00:00
Downloading numpy-1.23.5-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl
(17.1 MB)
17.1/17.1 MB 63.3 MB/s eta 0:00:00
Downloading pandas-1.5.3-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl
(12.1 MB)
12.1/12.1 MB 38.4 MB/s eta 0:00:00
Downloading tornado-6.3.2-cp38-abi3-manylinux_2_5_x86_64.manylinux1_x86_64.manylinux
_2_17_x86_64.manylinux2014_x86_64.whl (426 kB)
426.9/426.9 kB 27.3 MB/s eta 0:00:00
Installing collected packages: wcwidth, pytz, pure-eval, json5, fastjsonschema, execu
ting, appnope, websocket-client, webcolors, urllib3, uri-template, tzdata, traitlets,
tornado, tinycss2, soupsieve, sniffio, Send2Trash, rpds-py, rfc3986-validator, rfc333
9-validator, PyYAML, python-json-logger, pyparsing, Pygments, pycparser, prompt-toolk
it, prometheus-client, platformdirs, Pillow, pexpect, parso, pandocfilters, packagin
g, overrides, numpy, nest-asyncio, mistune, MarkupSafe, kiwisolver, jupyterlab-pygmen
ts, jsonpointer, idna, fqdn, fonttools, debugpy, cyclers, charset-normalizer, certifi,
bleach, Babel, attrs, async-lru, asttokens, terminado, stack-data, scipy, requests, r
eferencing, pandas, matplotlib-inline, jupyter_core, Jinja2, jedi, imageio, contourp
y, comm, cffi, beautifulsoup4, arrow, matplotlib, jupyter_server_terminals, jupyter_c
lient, jsonschema-specifications, isoduration, seaborn, jsonschema, nbformat, nbclien
t, jupyter-events, nbconvert, jupyter_server, notebook_shim, jupyterlab_server, jupyt
er-lsp, jupyterlab
Attempting uninstall: wcwidth
Found existing installation: wcwidth 0.2.13
Uninstalling wcwidth-0.2.13:
Successfully uninstalled wcwidth-0.2.13
Attempting uninstall: pytz
Found existing installation: pytz 2024.2
Uninstalling pytz-2024.2:
Successfully uninstalled pytz-2024.2
Attempting uninstall: fastjsonschema
Found existing installation: fastjsonschema 2.20.0
Uninstalling fastjsonschema-2.20.0:
Successfully uninstalled fastjsonschema-2.20.0
Attempting uninstall: websocket-client

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Found existing installation: websocket-client 1.8.0  
Uninstalling websocket-client-1.8.0:  
    Successfully uninstalled websocket-client-1.8.0  
Attempting uninstall: webcolors  
    Found existing installation: webcolors 24.8.0  
    Uninstalling webcolors-24.8.0:  
        Successfully uninstalled webcolors-24.8.0  
Attempting uninstall: urllib3  
    Found existing installation: urllib3 2.2.3  
    Uninstalling urllib3-2.2.3:  
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Attempting uninstall: tzdata  
    Found existing installation: tzdata 2024.1  
    Uninstalling tzdata-2024.1:  
        Successfully uninstalled tzdata-2024.1  
Attempting uninstall: traitlets  
    Found existing installation: traitlets 5.7.1  
    Uninstalling traitlets-5.7.1:  
        Successfully uninstalled traitlets-5.7.1  
Attempting uninstall: tornado  
    Found existing installation: tornado 6.3.3  
    Uninstalling tornado-6.3.3:  
        Successfully uninstalled tornado-6.3.3  
Attempting uninstall: tinycss2  
    Found existing installation: tinycss2 1.3.0  
    Uninstalling tinycss2-1.3.0:  
        Successfully uninstalled tinycss2-1.3.0  
Attempting uninstall: soupsieve  
    Found existing installation: soupsieve 2.6  
    Uninstalling soupsieve-2.6:  
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Attempting uninstall: sniffio  
    Found existing installation: sniffio 1.3.1  
    Uninstalling sniffio-1.3.1:  
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Attempting uninstall: Send2Trash  
    Found existing installation: Send2Trash 1.8.3  
    Uninstalling Send2Trash-1.8.3:  
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Attempting uninstall: rpds-py  
    Found existing installation: rpds-py 0.20.0  
    Uninstalling rpds-py-0.20.0:  
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Attempting uninstall: PyYAML  
    Found existing installation: PyYAML 6.0.2  
    Uninstalling PyYAML-6.0.2:  
        Successfully uninstalled PyYAML-6.0.2  
Attempting uninstall: pyparsing  
    Found existing installation: pyparsing 3.1.4  
    Uninstalling pyparsing-3.1.4:  
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Attempting uninstall: Pygments  
    Found existing installation: Pygments 2.18.0  
    Uninstalling Pygments-2.18.0:  
        Successfully uninstalled Pygments-2.18.0  
Attempting uninstall: pycparser  
    Found existing installation: pycparser 2.22  
    Uninstalling pycparser-2.22:  
        Successfully uninstalled pycparser-2.22  
Attempting uninstall: prompt-toolkit

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Found existing installation: prompt_toolkit 3.0.47
Uninstalling prompt_toolkit-3.0.47:
  Successfully uninstalled prompt_toolkit-3.0.47
Attempting uninstall: prometheus-client
Found existing installation: prometheus_client 0.21.0
Uninstalling prometheus_client-0.21.0:
  Successfully uninstalled prometheus_client-0.21.0
Attempting uninstall: platformdirs
Found existing installation: platformdirs 4.3.6
Uninstalling platformdirs-4.3.6:
  Successfully uninstalled platformdirs-4.3.6
Attempting uninstall: Pillow
Found existing installation: pillow 10.4.0
Uninstalling pillow-10.4.0:
  Successfully uninstalled pillow-10.4.0
Attempting uninstall: pexpect
Found existing installation: pexpect 4.9.0
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Attempting uninstall: parso
Found existing installation: parso 0.8.4
Uninstalling parso-0.8.4:
  Successfully uninstalled parso-0.8.4
Attempting uninstall: pandocfilters
Found existing installation: pandocfilters 1.5.1
Uninstalling pandocfilters-1.5.1:
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Attempting uninstall: packaging
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Attempting uninstall: numpy
Found existing installation: numpy 1.26.4
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Attempting uninstall: nest-asyncio
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Attempting uninstall: mistune
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Attempting uninstall: MarkupSafe
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Uninstalling MarkupSafe-2.1.5:
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Attempting uninstall: kiwisolver
Found existing installation: kiwisolver 1.4.7
Uninstalling kiwisolver-1.4.7:
  Successfully uninstalled kiwisolver-1.4.7
Attempting uninstall: jupyterlab-pygments
Found existing installation: jupyterlab_pygments 0.3.0
Uninstalling jupyterlab_pygments-0.3.0:
  Successfully uninstalled jupyterlab_pygments-0.3.0
Attempting uninstall: idna
Found existing installation: idna 3.10
Uninstalling idna-3.10:
  Successfully uninstalled idna-3.10
Attempting uninstall: fonttools
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Found existing installation: fonttools 4.53.1  
Uninstalling fonttools-4.53.1:  
    Successfully uninstalled fonttools-4.53.1  
Attempting uninstall: debugpy  
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Uninstalling debugpy-1.6.6:  
    Successfully uninstalled debugpy-1.6.6  
Attempting uninstall: cycler  
Found existing installation: cycler 0.12.1  
Uninstalling cycler-0.12.1:  
    Successfully uninstalled cycler-0.12.1  
Attempting uninstall: charset-normalizer  
Found existing installation: charset-normalizer 3.3.2  
Uninstalling charset-normalizer-3.3.2:  
    Successfully uninstalled charset-normalizer-3.3.2  
Attempting uninstall: certifi  
Found existing installation: certifi 2024.8.30  
Uninstalling certifi-2024.8.30:  
    Successfully uninstalled certifi-2024.8.30  
Attempting uninstall: bleach  
Found existing installation: bleach 6.1.0  
Uninstalling bleach-6.1.0:  
    Successfully uninstalled bleach-6.1.0  
Attempting uninstall: Babel  
Found existing installation: babel 2.16.0  
Uninstalling babel-2.16.0:  
    Successfully uninstalled babel-2.16.0  
Attempting uninstall: attrs  
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Attempting uninstall: terminado  
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Uninstalling terminado-0.18.1:  
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Attempting uninstall: scipy  
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    Successfully uninstalled scipy-1.13.1  
Attempting uninstall: requests  
Found existing installation: requests 2.32.3  
Uninstalling requests-2.32.3:  
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Attempting uninstall: referencing  
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Attempting uninstall: pandas  
Found existing installation: pandas 2.1.4  
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Attempting uninstall: matplotlib-inline  
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    Successfully uninstalled matplotlib-inline-0.1.7  
Attempting uninstall: jupyter\_core  
Found existing installation: jupyter\_core 5.7.2  
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    Successfully uninstalled jupyter\_core-5.7.2  
Attempting uninstall: Jinja2

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Found existing installation: Jinja2 3.1.4
Uninstalling Jinja2-3.1.4:
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Attempting uninstall: imageio
Found existing installation: imageio 2.35.1
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Attempting uninstall: contourpy
Found existing installation: contourpy 1.3.0
Uninstalling contourpy-1.3.0:
  Successfully uninstalled contourpy-1.3.0
Attempting uninstall: cffi
Found existing installation: cffi 1.17.1
Uninstalling cffi-1.17.1:
  Successfully uninstalled cffi-1.17.1
Attempting uninstall: beautifulsoup4
Found existing installation: beautifulsoup4 4.12.3
Uninstalling beautifulsoup4-4.12.3:
  Successfully uninstalled beautifulsoup4-4.12.3
Attempting uninstall: matplotlib
Found existing installation: matplotlib 3.7.1
Uninstalling matplotlib-3.7.1:
  Successfully uninstalled matplotlib-3.7.1
Attempting uninstall: jupyter_client
Found existing installation: jupyter-client 6.1.12
Uninstalling jupyter-client-6.1.12:
  Successfully uninstalled jupyter-client-6.1.12
Attempting uninstall: jsonschema-specifications
Found existing installation: jsonschema-specifications 2023.12.1
Uninstalling jsonschema-specifications-2023.12.1:
  Successfully uninstalled jsonschema-specifications-2023.12.1
Attempting uninstall: seaborn
Found existing installation: seaborn 0.13.1
Uninstalling seaborn-0.13.1:
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Attempting uninstall: jsonschema
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Uninstalling jsonschema-4.23.0:
  Successfully uninstalled jsonschema-4.23.0
Attempting uninstall: nbformat
Found existing installation: nbformat 5.10.4
Uninstalling nbformat-5.10.4:
  Successfully uninstalled nbformat-5.10.4
Attempting uninstall: nbclient
Found existing installation: nbclient 0.10.0
Uninstalling nbclient-0.10.0:
  Successfully uninstalled nbclient-0.10.0
Attempting uninstall: nbconvert
Found existing installation: nbconvert 6.5.4
Uninstalling nbconvert-6.5.4:
  Successfully uninstalled nbconvert-6.5.4
Attempting uninstall: jupyter_server
Found existing installation: jupyter-server 1.24.0
Uninstalling jupyter-server-1.24.0:
  Successfully uninstalled jupyter-server-1.24.0
Attempting uninstall: notebook_shim
Found existing installation: notebook_shim 0.2.4
Uninstalling notebook_shim-0.2.4:
  Successfully uninstalled notebook_shim-0.2.4
```

ERROR: pip's dependency resolver does not currently take into account all the package

s that are installed. This behaviour is the source of the following dependency conflicts.

albucore 0.0.16 requires numpy>=1.24, but you have numpy 1.23.5 which is incompatible.

alumentations 1.4.15 requires numpy>=1.24.4, but you have numpy 1.23.5 which is incompatible.

bigframes 1.18.0 requires numpy>=1.24.0, but you have numpy 1.23.5 which is incompatible.

bokeh 3.4.3 requires contourpy>=1.2, but you have contourpy 1.1.0 which is incompatible.

chex 0.1.86 requires numpy>=1.24.1, but you have numpy 1.23.5 which is incompatible.

cudf-cu12 24.4.1 requires pandas<2.2.2dev0,>=2.0, but you have pandas 1.5.3 which is incompatible.

google-colab 1.0.0 requires pandas==2.1.4, but you have pandas 1.5.3 which is incompatible.

google-colab 1.0.0 requires requests==2.32.3, but you have requests 2.31.0 which is incompatible.

google-colab 1.0.0 requires tornado==6.3.3, but you have tornado 6.3.2 which is incompatible.

jax 0.4.33 requires numpy>=1.24, but you have numpy 1.23.5 which is incompatible.

jaxlib 0.4.33 requires numpy>=1.24, but you have numpy 1.23.5 which is incompatible.

mizani 0.11.4 requires pandas>=2.1.0, but you have pandas 1.5.3 which is incompatible.

pandas-stubs 2.1.4.231227 requires numpy>=1.26.0; python\_version < "3.13", but you have numpy 1.23.5 which is incompatible.

plotnine 0.13.6 requires pandas<3.0.0,>=2.1.0, but you have pandas 1.5.3 which is incompatible.

scikit-image 0.24.0 requires imageio>=2.33, but you have imageio 2.31.1 which is incompatible.

xarray 2024.9.0 requires numpy>=1.24, but you have numpy 1.23.5 which is incompatible.

xarray 2024.9.0 requires pandas>=2.1, but you have pandas 1.5.3 which is incompatible.

Successfully installed Babel-2.12.1 Jinja2-3.1.2 MarkupSafe-2.1.3 Pillow-10.0.0 PyYAML-6.0.1 Pygments-2.16.1 Send2Trash-1.8.2 appnope-0.1.3 arrow-1.2.3 asttokens-2.2.1 asynclru-2.0.4 attrs-23.1.0 beautifulsoup4-4.12.2 bleach-6.0.0 certifi-2023.7.22 cffi-1.15.1 charset-normalizer-3.2.0 comm-0.1.4 contourpy-1.1.0 cycycler-0.11.0 debugpy-1.6.7.post1 executing-1.2.0 fastjsonschema-2.18.0 fonttools-4.42.1 fqdn-1.5.1 idna-3.4 imageio-2.31.1 isoduration-20.11.0 jedi-0.19.0 json5-0.9.14 jsonpointer-2.4 jsonschema-4.19.0 jsonschema-specifications-2023.7.1 jupyter-events-0.7.0 jupyter-lsp-2.2.0 jupyter\_client-7.4.9 jupyter\_core-5.3.1 jupyter\_server-2.7.2 jupyter\_server\_terminals-0.4.4 jupyterlab-4.0.5 jupyterlab-pygments-0.2.2 jupyterlab\_server-2.24.0 kiwisolver-1.4.5 matplotlib-3.7.2 matplotlib-inline-0.1.6 mistune-3.0.1 nbclient-0.8.0 nbconvert-7.7.4 nbformat-5.9.2 nest-asyncio-1.5.7 notebook\_shim-0.2.3 numpy-1.23.5 overrides-7.4.0 packaging-23.1 pandas-1.5.3 pandocfilters-1.5.0 parso-0.8.3 pexpect-4.8.0 platformdirs-3.10.0 prometheus-client-0.17.1 prompt-toolkit-3.0.39 pure-eval-0.2.2 pycparser-2.21 pyparsing-3.0.9 python-json-logger-2.0.7 pytz-2023.3 referencing-0.30.2 requests-2.31.0 rfc3339-validator-0.1.4 rfc3986-validator-0.1.1 rpds-py-0.9.2 scipy-1.11.2 seaborn-0.12.2 sniffio-1.3.0 soupsieve-2.4.1 stack-data-0.6.2 terminado-0.17.1 tinycss2-1.2.1 tornado-6.3.2 traitlets-5.9.0 tzdata-2023.3 uri-template-1.3.0 urllib3-2.0.4 wcwidth-0.2.6 webcolors-1.13 websocket-client-1.6.2

## Image features exercise

Complete and hand in this completed worksheet (including its outputs and any supporting code outside of the worksheet) with your assignment submission. For more details see the [assignments page](#) on the course website.



We have seen that we can achieve reasonable performance on an image classification task by training a linear classifier on the pixels of the input image. In this exercise we will show that we can improve our classification performance by training linear classifiers not on raw pixels but on features that are computed from the raw pixels.

All of your work for this exercise will be done in this notebook.

```
In [ ]: from __future__ import print_function
import random
import numpy as np
from cs6353.data_utils import load_CIFAR10
import matplotlib.pyplot as plt

%matplotlib inline
plt.rcParams['figure.figsize'] = (10.0, 8.0) # set default size of plots
plt.rcParams['image.interpolation'] = 'nearest'
plt.rcParams['image.cmap'] = 'gray'

# for auto-reloading external modules
# see http://stackoverflow.com/questions/1907993/autoreload-of-modules-in-ipython
%load_ext autoreload
%autoreload 2
```

## Load data

Similar to previous exercises, we will load CIFAR-10 data from disk.

```
In [ ]: from cs6353.features import color_histogram_hsv, hog_feature

def get_CIFAR10_data(cifar10_dir='cs6353/datasets/cifar-10-batches-py', num_training=4
    # Load the raw CIFAR-10 data
    X_train, y_train, X_test, y_test = load_CIFAR10(cifar10_dir)

    # Subsample the data
    mask = list(range(num_training, num_training + num_validation))
    X_val = X_train[mask]
    y_val = y_train[mask]
    mask = list(range(num_training))
    X_train = X_train[mask]
    y_train = y_train[mask]
    mask = list(range(num_test))
    X_test = X_test[mask]
    y_test = y_test[mask]

    return X_train, y_train, X_val, y_val, X_test, y_test

# Cleaning up variables to prevent loading data multiple times (which may cause memory
try:
    del X_train, y_train
    del X_test, y_test
    print('Clear previously loaded data.')
except:
    pass
```

```
#####
# TODO: Change the path of the CIFAR-10 data directory correctly to #
# the correct location #
# Default path is set to cs6353/datasets/cifar-10-batches-py' #
#####
cifar10_dir='cs6353/datasets/cifar-10-batches-py'
#####
#                               END OF YOUR CODE                               #
#####

X_train, y_train, X_val, y_val, X_test, y_test = get_CIFAR10_data(cifar10_dir)
```

## Extract Features

For each image we will compute a Histogram of Oriented Gradients (HOG) as well as a color histogram using the hue channel in HSV color space. We form our final feature vector for each image by concatenating the HOG and color histogram feature vectors.

Roughly speaking, HOG should capture the texture of the image while ignoring color information, and the color histogram represents the color of the input image while ignoring texture. As a result, we expect that using both together ought to work better than using either alone. Verifying this assumption would be a good thing to try for your interests.

The `hog_feature` and `color_histogram_hsv` functions both operate on a single image and return a feature vector for that image. The `extract_features` function takes a set of images and a list of feature functions and evaluates each feature function on each image, storing the results in a matrix where each column is the concatenation of all feature vectors for a single image.

```
In [ ]: from cs6353.features import *

num_color_bins = 10 # Number of bins in the color histogram
feature_fns = [hog_feature, lambda img: color_histogram_hsv(img, nbin=num_color_bins)]
X_train_feats = extract_features(X_train, feature_fns, verbose=True)
X_val_feats = extract_features(X_val, feature_fns)
X_test_feats = extract_features(X_test, feature_fns)

# Preprocessing: Subtract the mean feature
mean_feat = np.mean(X_train_feats, axis=0, keepdims=True)
X_train_feats -= mean_feat
X_val_feats -= mean_feat
X_test_feats -= mean_feat

# Preprocessing: Divide by standard deviation. This ensures that each feature
# has roughly the same scale.
std_feat = np.std(X_train_feats, axis=0, keepdims=True)
X_train_feats /= std_feat
X_val_feats /= std_feat
X_test_feats /= std_feat

# Preprocessing: Add a bias dimension
X_train_feats = np.hstack([X_train_feats, np.ones((X_train_feats.shape[0], 1))])
X_val_feats = np.hstack([X_val_feats, np.ones((X_val_feats.shape[0], 1))])
X_test_feats = np.hstack([X_test_feats, np.ones((X_test_feats.shape[0], 1))])
```

```
Done extracting features for 1000 / 49000 images
Done extracting features for 2000 / 49000 images
Done extracting features for 3000 / 49000 images
Done extracting features for 4000 / 49000 images
Done extracting features for 5000 / 49000 images
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Done extracting features for 45000 / 49000 images
Done extracting features for 46000 / 49000 images
Done extracting features for 47000 / 49000 images
Done extracting features for 48000 / 49000 images
```

## Train SVM on features

Using the multiclass SVM code developed earlier in the assignment, train SVMs on top of the features extracted above; this should achieve better results than training SVMs directly on top of raw pixels.

```
In [ ]: # Use the validation set to tune the learning rate and regularization strength
```

```

from cs6353.classifiers.linear_classifier import LinearSVM

learning_rates = [1e-7, 1e-5, 1e-4, 1e-3, 2e-7]
regularization_strengths = [1, 1e-1, 2e-1, 5e-1, 1e-2, 5e3]

results = {}
best_val = -1
best_svm = None

#####
# TODO:
# Use the validation set to set the learning rate and regularization strength. #
# This should be identical to the validation that you did for the SVM; save #
# the best trained classifier in best_svm. You might also want to play #
# with different numbers of bins in the color histogram. If you are careful #
# you should be able to get accuracy of near 0.44 on the validation set. #
#####
for lr in learning_rates:
    for reg in regularization_strengths:

        svm = LinearSVM()

        svm.train(X_train_feats, y_train, learning_rate=lr, reg=reg, num_iters=1500, v

        y_train_pred = svm.predict(X_train_feats)
        y_val_pred = svm.predict(X_val_feats)

        train_results = y_train_pred == y_train
        y_train_accuracy = np.mean(train_results)

        val_results = y_val_pred == y_val
        y_val_accuracy = np.mean(val_results)

        results[(lr, reg)] = (y_train_accuracy, y_val_accuracy)

        if y_val_accuracy > best_val:
            best_val = y_val_accuracy
            best_svm = svm

#####
#                                     END OF YOUR CODE                                     #
#####

# Print out results.
for lr, reg in sorted(results):
    train_accuracy, val_accuracy = results[(lr, reg)]
    print('lr %e reg %e train accuracy: %f val accuracy: %f' % (
        lr, reg, train_accuracy, val_accuracy))

print('best validation accuracy achieved during cross-validation: %f' % best_val)

```

```
iteration 0 / 1500: loss 9.013532
iteration 100 / 1500: loss 9.005905
iteration 200 / 1500: loss 8.999067
iteration 300 / 1500: loss 9.010873
iteration 400 / 1500: loss 9.012125
iteration 500 / 1500: loss 9.006480
iteration 600 / 1500: loss 8.998394
iteration 700 / 1500: loss 8.996802
iteration 800 / 1500: loss 9.006092
iteration 900 / 1500: loss 9.003871
iteration 1000 / 1500: loss 9.006651
iteration 1100 / 1500: loss 8.996429
iteration 1200 / 1500: loss 8.993661
iteration 1300 / 1500: loss 8.987182
iteration 1400 / 1500: loss 8.996445
iteration 0 / 1500: loss 9.000013
iteration 100 / 1500: loss 8.995990
iteration 200 / 1500: loss 8.995294
iteration 300 / 1500: loss 9.006803
iteration 400 / 1500: loss 8.995009
iteration 500 / 1500: loss 8.987107
iteration 600 / 1500: loss 8.997460
iteration 700 / 1500: loss 8.988426
iteration 800 / 1500: loss 8.985681
iteration 900 / 1500: loss 8.985636
iteration 1000 / 1500: loss 8.997433
iteration 1100 / 1500: loss 8.983115
iteration 1200 / 1500: loss 8.985105
iteration 1300 / 1500: loss 8.993259
iteration 1400 / 1500: loss 8.993054
iteration 0 / 1500: loss 8.998570
iteration 100 / 1500: loss 8.971324
iteration 200 / 1500: loss 8.997724
iteration 300 / 1500: loss 8.982777
iteration 400 / 1500: loss 9.003107
iteration 500 / 1500: loss 9.001476
iteration 600 / 1500: loss 8.985405
iteration 700 / 1500: loss 8.991129
iteration 800 / 1500: loss 8.990169
iteration 900 / 1500: loss 8.989853
iteration 1000 / 1500: loss 8.997513
iteration 1100 / 1500: loss 8.988364
iteration 1200 / 1500: loss 8.981983
iteration 1300 / 1500: loss 8.979658
iteration 1400 / 1500: loss 8.979322
iteration 0 / 1500: loss 9.020787
iteration 100 / 1500: loss 9.017756
iteration 200 / 1500: loss 9.009067
iteration 300 / 1500: loss 9.011930
iteration 400 / 1500: loss 9.004455
iteration 500 / 1500: loss 9.006968
iteration 600 / 1500: loss 9.006946
iteration 700 / 1500: loss 9.016035
iteration 800 / 1500: loss 9.002542
iteration 900 / 1500: loss 9.010131
iteration 1000 / 1500: loss 9.013870
iteration 1100 / 1500: loss 8.998080
iteration 1200 / 1500: loss 9.014795
iteration 1300 / 1500: loss 8.999988
iteration 1400 / 1500: loss 9.006232
```

```
iteration 0 / 1500: loss 8.992293
iteration 100 / 1500: loss 9.003871
iteration 200 / 1500: loss 9.006667
iteration 300 / 1500: loss 9.015637
iteration 400 / 1500: loss 9.006338
iteration 500 / 1500: loss 9.003154
iteration 600 / 1500: loss 8.997350
iteration 700 / 1500: loss 8.987879
iteration 800 / 1500: loss 8.982116
iteration 900 / 1500: loss 9.008131
iteration 1000 / 1500: loss 8.997903
iteration 1100 / 1500: loss 9.001313
iteration 1200 / 1500: loss 8.991351
iteration 1300 / 1500: loss 8.986975
iteration 1400 / 1500: loss 8.998100
iteration 0 / 1500: loss 16.445010
iteration 100 / 1500: loss 15.079379
iteration 200 / 1500: loss 13.983241
iteration 300 / 1500: loss 13.073827
iteration 400 / 1500: loss 12.329636
iteration 500 / 1500: loss 11.722678
iteration 600 / 1500: loss 11.230366
iteration 700 / 1500: loss 10.831539
iteration 800 / 1500: loss 10.500262
iteration 900 / 1500: loss 10.227037
iteration 1000 / 1500: loss 10.003496
iteration 1100 / 1500: loss 9.818231
iteration 1200 / 1500: loss 9.669582
iteration 1300 / 1500: loss 9.547674
iteration 1400 / 1500: loss 9.450321
iteration 0 / 1500: loss 8.975145
iteration 100 / 1500: loss 8.896527
iteration 200 / 1500: loss 8.834638
iteration 300 / 1500: loss 8.775904
iteration 400 / 1500: loss 8.694544
iteration 500 / 1500: loss 8.638067
iteration 600 / 1500: loss 8.543439
iteration 700 / 1500: loss 8.438022
iteration 800 / 1500: loss 8.474371
iteration 900 / 1500: loss 8.313164
iteration 1000 / 1500: loss 8.326647
iteration 1100 / 1500: loss 8.207184
iteration 1200 / 1500: loss 8.155812
iteration 1300 / 1500: loss 8.114780
iteration 1400 / 1500: loss 8.070573
iteration 0 / 1500: loss 9.000184
iteration 100 / 1500: loss 8.944632
iteration 200 / 1500: loss 8.865356
iteration 300 / 1500: loss 8.796489
iteration 400 / 1500: loss 8.741757
iteration 500 / 1500: loss 8.624932
iteration 600 / 1500: loss 8.556358
iteration 700 / 1500: loss 8.498920
iteration 800 / 1500: loss 8.419911
iteration 900 / 1500: loss 8.314671
iteration 1000 / 1500: loss 8.255334
iteration 1100 / 1500: loss 8.307116
iteration 1200 / 1500: loss 8.238507
iteration 1300 / 1500: loss 8.061611
iteration 1400 / 1500: loss 8.078579
```

```
iteration 0 / 1500: loss 8.979697
iteration 100 / 1500: loss 8.907890
iteration 200 / 1500: loss 8.843051
iteration 300 / 1500: loss 8.779633
iteration 400 / 1500: loss 8.724639
iteration 500 / 1500: loss 8.623214
iteration 600 / 1500: loss 8.565148
iteration 700 / 1500: loss 8.506168
iteration 800 / 1500: loss 8.374103
iteration 900 / 1500: loss 8.340418
iteration 1000 / 1500: loss 8.256675
iteration 1100 / 1500: loss 8.258177
iteration 1200 / 1500: loss 8.175996
iteration 1300 / 1500: loss 7.962400
iteration 1400 / 1500: loss 8.021050
iteration 0 / 1500: loss 8.990459
iteration 100 / 1500: loss 8.937378
iteration 200 / 1500: loss 8.837634
iteration 300 / 1500: loss 8.780671
iteration 400 / 1500: loss 8.691435
iteration 500 / 1500: loss 8.618017
iteration 600 / 1500: loss 8.532597
iteration 700 / 1500: loss 8.531897
iteration 800 / 1500: loss 8.381886
iteration 900 / 1500: loss 8.282453
iteration 1000 / 1500: loss 8.281086
iteration 1100 / 1500: loss 8.268697
iteration 1200 / 1500: loss 8.118914
iteration 1300 / 1500: loss 8.096367
iteration 1400 / 1500: loss 7.982691
iteration 0 / 1500: loss 8.993519
iteration 100 / 1500: loss 8.950262
iteration 200 / 1500: loss 8.859969
iteration 300 / 1500: loss 8.815860
iteration 400 / 1500: loss 8.701106
iteration 500 / 1500: loss 8.628908
iteration 600 / 1500: loss 8.587463
iteration 700 / 1500: loss 8.503385
iteration 800 / 1500: loss 8.444351
iteration 900 / 1500: loss 8.376981
iteration 1000 / 1500: loss 8.224956
iteration 1100 / 1500: loss 8.142255
iteration 1200 / 1500: loss 8.129663
iteration 1300 / 1500: loss 8.132952
iteration 1400 / 1500: loss 7.974167
iteration 0 / 1500: loss 16.745371
iteration 100 / 1500: loss 8.997250
iteration 200 / 1500: loss 8.996818
iteration 300 / 1500: loss 8.997674
iteration 400 / 1500: loss 8.996294
iteration 500 / 1500: loss 8.996386
iteration 600 / 1500: loss 8.996522
iteration 700 / 1500: loss 8.997703
iteration 800 / 1500: loss 8.996459
iteration 900 / 1500: loss 8.996154
iteration 1000 / 1500: loss 8.996721
iteration 1100 / 1500: loss 8.997367
iteration 1200 / 1500: loss 8.996567
iteration 1300 / 1500: loss 8.996511
iteration 1400 / 1500: loss 8.997005
```



iteration 0 / 1500: loss 8.998873  
iteration 100 / 1500: loss 8.211621  
iteration 200 / 1500: loss 7.751104  
iteration 300 / 1500: loss 7.285559  
iteration 400 / 1500: loss 6.727619  
iteration 500 / 1500: loss 6.215527  
iteration 600 / 1500: loss 6.037269  
iteration 700 / 1500: loss 5.224562  
iteration 800 / 1500: loss 5.672082  
iteration 900 / 1500: loss 5.022154  
iteration 1000 / 1500: loss 5.708719  
iteration 1100 / 1500: loss 5.580490  
iteration 1200 / 1500: loss 5.462514  
iteration 1300 / 1500: loss 5.353922  
iteration 1400 / 1500: loss 4.728410  
iteration 0 / 1500: loss 9.013173  
iteration 100 / 1500: loss 8.322357  
iteration 200 / 1500: loss 7.673927  
iteration 300 / 1500: loss 6.920234  
iteration 400 / 1500: loss 6.174442  
iteration 500 / 1500: loss 6.117465  
iteration 600 / 1500: loss 5.860024  
iteration 700 / 1500: loss 5.276261  
iteration 800 / 1500: loss 4.905651  
iteration 900 / 1500: loss 4.950825  
iteration 1000 / 1500: loss 5.097077  
iteration 1100 / 1500: loss 5.222958  
iteration 1200 / 1500: loss 4.436571  
iteration 1300 / 1500: loss 5.081638  
iteration 1400 / 1500: loss 4.419436  
iteration 0 / 1500: loss 8.992998  
iteration 100 / 1500: loss 8.298625  
iteration 200 / 1500: loss 7.548628  
iteration 300 / 1500: loss 6.753199  
iteration 400 / 1500: loss 6.312741  
iteration 500 / 1500: loss 6.110861  
iteration 600 / 1500: loss 5.904919  
iteration 700 / 1500: loss 5.725787  
iteration 800 / 1500: loss 5.394149  
iteration 900 / 1500: loss 4.801168  
iteration 1000 / 1500: loss 5.104601  
iteration 1100 / 1500: loss 4.775095  
iteration 1200 / 1500: loss 4.671688  
iteration 1300 / 1500: loss 4.504473  
iteration 1400 / 1500: loss 4.531796  
iteration 0 / 1500: loss 8.983970  
iteration 100 / 1500: loss 8.133287  
iteration 200 / 1500: loss 7.559833  
iteration 300 / 1500: loss 6.921541  
iteration 400 / 1500: loss 6.128608  
iteration 500 / 1500: loss 6.026581  
iteration 600 / 1500: loss 5.617900  
iteration 700 / 1500: loss 6.094780  
iteration 800 / 1500: loss 5.027963  
iteration 900 / 1500: loss 5.152269  
iteration 1000 / 1500: loss 5.017656  
iteration 1100 / 1500: loss 4.984861  
iteration 1200 / 1500: loss 4.733104  
iteration 1300 / 1500: loss 4.907429  
iteration 1400 / 1500: loss 4.971434

```
iteration 0 / 1500: loss 8.998810
iteration 100 / 1500: loss 8.317201
iteration 200 / 1500: loss 7.486032
iteration 300 / 1500: loss 6.671095
iteration 400 / 1500: loss 6.339828
iteration 500 / 1500: loss 6.070355
iteration 600 / 1500: loss 5.434010
iteration 700 / 1500: loss 5.379509
iteration 800 / 1500: loss 5.075093
iteration 900 / 1500: loss 5.058158
iteration 1000 / 1500: loss 4.610936
iteration 1100 / 1500: loss 4.607124
iteration 1200 / 1500: loss 4.881768
iteration 1300 / 1500: loss 4.450071
iteration 1400 / 1500: loss 4.446012
iteration 0 / 1500: loss 16.844162
iteration 100 / 1500: loss 9.000173
iteration 200 / 1500: loss 8.999393
iteration 300 / 1500: loss 9.000491
iteration 400 / 1500: loss 9.000237
iteration 500 / 1500: loss 8.999904
iteration 600 / 1500: loss 8.999456
iteration 700 / 1500: loss 9.001182
iteration 800 / 1500: loss 8.999983
iteration 900 / 1500: loss 9.001006
iteration 1000 / 1500: loss 9.000078
iteration 1100 / 1500: loss 9.000734
iteration 1200 / 1500: loss 8.998640
iteration 1300 / 1500: loss 8.998972
iteration 1400 / 1500: loss 8.999032
iteration 0 / 1500: loss 9.008268
iteration 100 / 1500: loss 5.530308
iteration 200 / 1500: loss 5.125856
iteration 300 / 1500: loss 4.659448
iteration 400 / 1500: loss 4.841204
iteration 500 / 1500: loss 4.636888
iteration 600 / 1500: loss 4.829179
iteration 700 / 1500: loss 4.889966
iteration 800 / 1500: loss 4.827435
iteration 900 / 1500: loss 4.832629
iteration 1000 / 1500: loss 4.838947
iteration 1100 / 1500: loss 5.397892
iteration 1200 / 1500: loss 4.713454
iteration 1300 / 1500: loss 4.880191
iteration 1400 / 1500: loss 5.267529
iteration 0 / 1500: loss 8.986719
iteration 100 / 1500: loss 5.197790
iteration 200 / 1500: loss 4.804896
iteration 300 / 1500: loss 3.842488
iteration 400 / 1500: loss 3.791836
iteration 500 / 1500: loss 3.936980
iteration 600 / 1500: loss 3.780975
iteration 700 / 1500: loss 3.537026
iteration 800 / 1500: loss 3.145250
iteration 900 / 1500: loss 3.205181
iteration 1000 / 1500: loss 3.314481
iteration 1100 / 1500: loss 3.523786
iteration 1200 / 1500: loss 2.974993
iteration 1300 / 1500: loss 3.377697
iteration 1400 / 1500: loss 3.346372
```

```
iteration 0 / 1500: loss 9.012271
iteration 100 / 1500: loss 4.683300
iteration 200 / 1500: loss 4.280253
iteration 300 / 1500: loss 3.925573
iteration 400 / 1500: loss 3.610590
iteration 500 / 1500: loss 3.916129
iteration 600 / 1500: loss 3.948670
iteration 700 / 1500: loss 3.941106
iteration 800 / 1500: loss 3.777270
iteration 900 / 1500: loss 3.651549
iteration 1000 / 1500: loss 3.778945
iteration 1100 / 1500: loss 4.017471
iteration 1200 / 1500: loss 3.920450
iteration 1300 / 1500: loss 3.418260
iteration 1400 / 1500: loss 3.672257
iteration 0 / 1500: loss 8.996609
iteration 100 / 1500: loss 4.958472
iteration 200 / 1500: loss 4.414333
iteration 300 / 1500: loss 4.408473
iteration 400 / 1500: loss 3.975846
iteration 500 / 1500: loss 4.201985
iteration 600 / 1500: loss 4.546119
iteration 700 / 1500: loss 4.396723
iteration 800 / 1500: loss 4.417406
iteration 900 / 1500: loss 4.000232
iteration 1000 / 1500: loss 4.158696
iteration 1100 / 1500: loss 4.500879
iteration 1200 / 1500: loss 3.922109
iteration 1300 / 1500: loss 4.458384
iteration 1400 / 1500: loss 4.117051
iteration 0 / 1500: loss 8.995200
iteration 100 / 1500: loss 5.119368
iteration 200 / 1500: loss 3.472156
iteration 300 / 1500: loss 3.869788
iteration 400 / 1500: loss 3.524658
iteration 500 / 1500: loss 3.423991
iteration 600 / 1500: loss 3.785522
iteration 700 / 1500: loss 3.408188
iteration 800 / 1500: loss 3.604609
iteration 900 / 1500: loss 3.154217
iteration 1000 / 1500: loss 3.066422
iteration 1100 / 1500: loss 3.364834
iteration 1200 / 1500: loss 3.153840
iteration 1300 / 1500: loss 3.339472
iteration 1400 / 1500: loss 2.779781
iteration 0 / 1500: loss 16.692660
iteration 100 / 1500: loss 5432540045339055261188022265079119509313939275896963849584
4560278167174515637554374574713126125350384537236711829092834056260251402653378456210
4262418698034048090222360572857565483370427711488.000000
iteration 200 / 1500: loss inf
iteration 300 / 1500: loss inf
iteration 400 / 1500: loss nan
```

```
/content/drive/MyDrive/CS6353/Assignments/assignment2/assignment2/cs6353/classifiers/
linear_svm.py:100: RuntimeWarning: overflow encountered in scalar multiply
    loss += reg * np.sum(W * W)
/usr/local/lib/python3.10/dist-packages/numpy/core/fromnumeric.py:88: RuntimeWarning:
overflow encountered in reduce

/content/drive/MyDrive/CS6353/Assignments/assignment2/assignment2/cs6353/classifiers/
linear_svm.py:100: RuntimeWarning: overflow encountered in multiply
    loss += reg * np.sum(W * W)
/content/drive/MyDrive/CS6353/Assignments/assignment2/assignment2/cs6353/classifiers/
linear_svm.py:125: RuntimeWarning: overflow encountered in multiply
    dW += 2 * reg * W
/content/drive/MyDrive/CS6353/Assignments/assignment2/assignment2/cs6353/classifiers/
linear_classifier.py:70: RuntimeWarning: invalid value encountered in subtract
    self.W -= learning_rate * grad
```

```
iteration 500 / 1500: loss nan
iteration 600 / 1500: loss nan
iteration 700 / 1500: loss nan
iteration 800 / 1500: loss nan
iteration 900 / 1500: loss nan
iteration 1000 / 1500: loss nan
iteration 1100 / 1500: loss nan
iteration 1200 / 1500: loss nan
iteration 1300 / 1500: loss nan
iteration 1400 / 1500: loss nan
iteration 0 / 1500: loss 8.979867
iteration 100 / 1500: loss 8.996251
iteration 200 / 1500: loss 9.001369
iteration 300 / 1500: loss 8.980656
iteration 400 / 1500: loss 8.981561
iteration 500 / 1500: loss 8.991502
iteration 600 / 1500: loss 8.959770
iteration 700 / 1500: loss 8.987205
iteration 800 / 1500: loss 8.983566
iteration 900 / 1500: loss 8.986715
iteration 1000 / 1500: loss 8.981800
iteration 1100 / 1500: loss 8.968632
iteration 1200 / 1500: loss 8.956905
iteration 1300 / 1500: loss 8.979529
iteration 1400 / 1500: loss 8.977704
iteration 0 / 1500: loss 8.998422
iteration 100 / 1500: loss 8.985798
iteration 200 / 1500: loss 8.977414
iteration 300 / 1500: loss 8.982007
iteration 400 / 1500: loss 8.981535
iteration 500 / 1500: loss 8.980430
iteration 600 / 1500: loss 8.981968
iteration 700 / 1500: loss 8.979893
iteration 800 / 1500: loss 8.966357
iteration 900 / 1500: loss 8.966229
iteration 1000 / 1500: loss 8.976326
iteration 1100 / 1500: loss 8.984724
iteration 1200 / 1500: loss 8.966523
iteration 1300 / 1500: loss 8.988293
iteration 1400 / 1500: loss 8.977714
iteration 0 / 1500: loss 9.011928
iteration 100 / 1500: loss 9.015683
iteration 200 / 1500: loss 9.009162
iteration 300 / 1500: loss 8.990739
iteration 400 / 1500: loss 9.006050
iteration 500 / 1500: loss 9.002419
iteration 600 / 1500: loss 8.984172
iteration 700 / 1500: loss 9.013493
iteration 800 / 1500: loss 8.995792
iteration 900 / 1500: loss 9.005634
iteration 1000 / 1500: loss 8.984671
iteration 1100 / 1500: loss 8.989461
iteration 1200 / 1500: loss 8.991261
iteration 1300 / 1500: loss 8.983193
iteration 1400 / 1500: loss 8.981880
iteration 0 / 1500: loss 8.985978
iteration 100 / 1500: loss 9.013909
iteration 200 / 1500: loss 9.004129
iteration 300 / 1500: loss 8.995814
iteration 400 / 1500: loss 8.986354
```

```
iteration 500 / 1500: loss 8.992970
iteration 600 / 1500: loss 8.992309
iteration 700 / 1500: loss 8.989405
iteration 800 / 1500: loss 8.986906
iteration 900 / 1500: loss 8.982426
iteration 1000 / 1500: loss 8.975887
iteration 1100 / 1500: loss 8.983723
iteration 1200 / 1500: loss 8.980348
iteration 1300 / 1500: loss 8.975027
iteration 1400 / 1500: loss 8.960443
iteration 0 / 1500: loss 9.001468
iteration 100 / 1500: loss 9.014731
iteration 200 / 1500: loss 8.998339
iteration 300 / 1500: loss 8.998015
iteration 400 / 1500: loss 8.990683
iteration 500 / 1500: loss 8.991826
iteration 600 / 1500: loss 8.984588
iteration 700 / 1500: loss 8.984822
iteration 800 / 1500: loss 8.990561
iteration 900 / 1500: loss 8.981084
iteration 1000 / 1500: loss 8.977509
iteration 1100 / 1500: loss 8.970272
iteration 1200 / 1500: loss 8.982036
iteration 1300 / 1500: loss 8.977331
iteration 1400 / 1500: loss 8.988174
iteration 0 / 1500: loss 17.012696
iteration 100 / 1500: loss 14.360557
iteration 200 / 1500: loss 12.591737
iteration 300 / 1500: loss 11.406741
iteration 400 / 1500: loss 10.606751
iteration 500 / 1500: loss 10.077585
iteration 600 / 1500: loss 9.722681
iteration 700 / 1500: loss 9.484263
iteration 800 / 1500: loss 9.323231
iteration 900 / 1500: loss 9.214641
iteration 1000 / 1500: loss 9.141867
iteration 1100 / 1500: loss 9.093606
iteration 1200 / 1500: loss 9.060933
iteration 1300 / 1500: loss 9.040592
iteration 1400 / 1500: loss 9.026970
lr 1.000000e-07 reg 1.000000e-02 train accuracy: 0.111816 val accuracy: 0.100000
lr 1.000000e-07 reg 1.000000e-01 train accuracy: 0.122163 val accuracy: 0.113000
lr 1.000000e-07 reg 2.000000e-01 train accuracy: 0.126980 val accuracy: 0.123000
lr 1.000000e-07 reg 5.000000e-01 train accuracy: 0.088551 val accuracy: 0.082000
lr 1.000000e-07 reg 1.000000e+00 train accuracy: 0.105776 val accuracy: 0.114000
lr 1.000000e-07 reg 5.000000e+03 train accuracy: 0.147490 val accuracy: 0.138000
lr 2.000000e-07 reg 1.000000e-02 train accuracy: 0.141531 val accuracy: 0.139000
lr 2.000000e-07 reg 1.000000e-01 train accuracy: 0.141959 val accuracy: 0.156000
lr 2.000000e-07 reg 2.000000e-01 train accuracy: 0.126653 val accuracy: 0.116000
lr 2.000000e-07 reg 5.000000e-01 train accuracy: 0.130714 val accuracy: 0.161000
lr 2.000000e-07 reg 1.000000e+00 train accuracy: 0.155041 val accuracy: 0.144000
lr 2.000000e-07 reg 5.000000e+03 train accuracy: 0.272918 val accuracy: 0.261000
lr 1.000000e-05 reg 1.000000e-02 train accuracy: 0.406796 val accuracy: 0.396000
lr 1.000000e-05 reg 1.000000e-01 train accuracy: 0.408510 val accuracy: 0.410000
lr 1.000000e-05 reg 2.000000e-01 train accuracy: 0.409163 val accuracy: 0.414000
lr 1.000000e-05 reg 5.000000e-01 train accuracy: 0.407816 val accuracy: 0.410000
lr 1.000000e-05 reg 1.000000e+00 train accuracy: 0.408490 val accuracy: 0.400000
lr 1.000000e-05 reg 5.000000e+03 train accuracy: 0.407367 val accuracy: 0.410000
lr 1.000000e-04 reg 1.000000e-02 train accuracy: 0.451776 val accuracy: 0.443000
lr 1.000000e-04 reg 1.000000e-01 train accuracy: 0.451367 val accuracy: 0.448000
```

```

lr 1.000000e-04 reg 2.000000e-01 train accuracy: 0.449531 val accuracy: 0.449000
lr 1.000000e-04 reg 5.000000e-01 train accuracy: 0.450388 val accuracy: 0.446000
lr 1.000000e-04 reg 1.000000e+00 train accuracy: 0.448592 val accuracy: 0.441000
lr 1.000000e-04 reg 5.000000e+03 train accuracy: 0.332102 val accuracy: 0.348000
lr 1.000000e-03 reg 1.000000e-02 train accuracy: 0.500061 val accuracy: 0.492000
lr 1.000000e-03 reg 1.000000e-01 train accuracy: 0.499041 val accuracy: 0.493000
lr 1.000000e-03 reg 2.000000e-01 train accuracy: 0.498041 val accuracy: 0.487000
lr 1.000000e-03 reg 5.000000e-01 train accuracy: 0.490449 val accuracy: 0.476000
lr 1.000000e-03 reg 1.000000e+00 train accuracy: 0.484878 val accuracy: 0.474000
lr 1.000000e-03 reg 5.000000e+03 train accuracy: 0.100265 val accuracy: 0.087000
best validation accuracy achieved during cross-validation: 0.493000

```

```

In [ ]: # Evaluate your trained SVM on the test set
y_test_pred = best_svm.predict(X_test_feats)
test_accuracy = np.mean(y_test == y_test_pred)
print(test_accuracy)

```

0.48

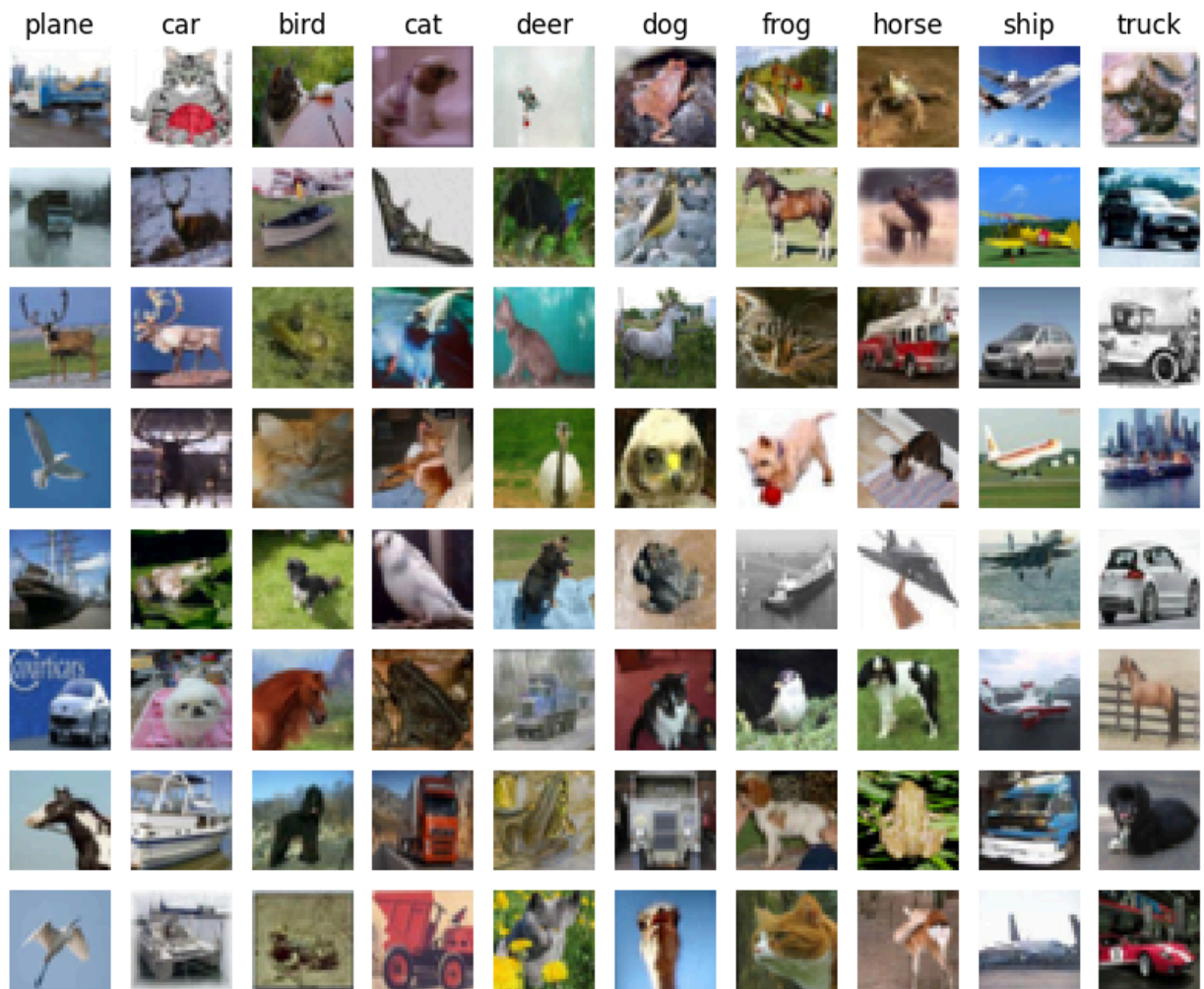
```

In [ ]: # An important way to gain intuition about how an algorithm works is to
# visualize the mistakes that it makes. In this visualization, we show examples
# of images that are misclassified by our current system. The first column
# shows images that our system labeled as "plane" but whose true label is
# something other than "plane".

examples_per_class = 8
classes = ['plane', 'car', 'bird', 'cat', 'deer', 'dog', 'frog', 'horse', 'ship', 'truck']
for cls, cls_name in enumerate(classes):
    idxs = np.where((y_test != cls) & (y_test_pred == cls))[0]
    idxs = np.random.choice(idxs, examples_per_class, replace=False)
    for i, idx in enumerate(idxs):
        plt.subplot(examples_per_class, len(classes), i * len(classes) + cls + 1)
        plt.imshow(X_test[idx].astype('uint8'))
        plt.axis('off')
        if i == 0:
            plt.title(cls_name)
plt.show()

```





# Neural Network on image features

Earlier in this assignment we saw that training a two-layer neural network on raw pixels achieved better classification performance than linear classifiers on raw pixels. In this notebook we have seen that linear classifiers on image features outperform linear classifiers on raw pixels.

For completeness, we should also try training a neural network on image features. This approach should outperform all previous approaches: you should easily be able to achieve over 55% classification accuracy on the test set; our best model achieves about 60% classification accuracy.

```
In [ ]: # Preprocessing: Remove the bias dimension
# Make sure to run this cell only ONCE
print(X_train_feats.shape)
X_train_feats = X_train_feats[:, :-1]
X_val_feats = X_val_feats[:, :-1]
X_test_feats = X_test_feats[:, :-1]

print(X_train_feats.shape)

(49000, 155)
(49000, 154)
```

```
In [ ]: from cs6353.classifiers.neural_net import TwoLayerNet

input_dim = X_train_feats.shape[1]
hidden_dim = 500
num_classes = 10

net = TwoLayerNet(input_dim, hidden_dim, num_classes)
best_net = None

#####
# TODO: Train a two-layer neural network on image features. You may want to #
# cross-validate various parameters as in previous sections. Store your best #
# model in the best_net variable. #
#####
learning_rates = [3e-1, 1e-2, 2e-3]
regularization_strengths = [2e-7, 1e-7, 2e-5]
hidden_layer_sizes = [100, 150, 175]
num_of_epochs = [1500, 3000]
results = {}
best_val = -1

for lr in learning_rates:
    for reg in regularization_strengths:
        for hls in hidden_layer_sizes:
            for epochs in num_of_epochs:

                net = TwoLayerNet(input_dim, hls, num_classes)

                stats = net.train(X_train_feats, y_train, X_val_feats, y_val,
                                num_iters=epochs, batch_size=200,
                                learning_rate=lr, learning_rate_decay=0.95,
                                reg=reg, verbose=True)
```

```
y_train_pred = net.predict(X_train_feats)
y_val_pred = net.predict(X_val_feats)

train_acc = np.mean(y_train_pred == y_train)
val_acc = np.mean(y_val_pred == y_val)

results[(lr, reg, hls, epochs)] = (train_acc, val_acc)
print(lr, reg, hls, epochs, train_acc, val_acc)

if val_acc > best_val:
    best_val = val_acc
    best_net = net

#####
#                               END OF YOUR CODE                               #
#####
```

```
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 1.837699
iteration 200 / 1500: loss 1.430180
iteration 300 / 1500: loss 1.461022
iteration 400 / 1500: loss 1.337830
iteration 500 / 1500: loss 1.316799
iteration 600 / 1500: loss 1.329158
iteration 700 / 1500: loss 1.259146
iteration 800 / 1500: loss 1.408602
iteration 900 / 1500: loss 1.379886
iteration 1000 / 1500: loss 1.123509
iteration 1100 / 1500: loss 1.109656
iteration 1200 / 1500: loss 1.054326
iteration 1300 / 1500: loss 1.163406
iteration 1400 / 1500: loss 1.215077
0.3 2e-07 100 1500 0.6139591836734694 0.572
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 1.921849
iteration 200 / 3000: loss 1.503588
iteration 300 / 3000: loss 1.250968
iteration 400 / 3000: loss 1.316346
iteration 500 / 3000: loss 1.273989
iteration 600 / 3000: loss 1.394202
iteration 700 / 3000: loss 1.367919
iteration 800 / 3000: loss 1.254400
iteration 900 / 3000: loss 1.148793
iteration 1000 / 3000: loss 1.215016
iteration 1100 / 3000: loss 1.107165
iteration 1200 / 3000: loss 1.201162
iteration 1300 / 3000: loss 1.124361
iteration 1400 / 3000: loss 1.127846
iteration 1500 / 3000: loss 1.118782
iteration 1600 / 3000: loss 1.054724
iteration 1700 / 3000: loss 1.089153
iteration 1800 / 3000: loss 1.006425
iteration 1900 / 3000: loss 0.993421
iteration 2000 / 3000: loss 1.038893
iteration 2100 / 3000: loss 1.058492
iteration 2200 / 3000: loss 1.082460
iteration 2300 / 3000: loss 1.161133
iteration 2400 / 3000: loss 1.076711
iteration 2500 / 3000: loss 1.013445
iteration 2600 / 3000: loss 0.984464
iteration 2700 / 3000: loss 1.010282
iteration 2800 / 3000: loss 1.090771
iteration 2900 / 3000: loss 1.057545
0.3 2e-07 100 3000 0.6583061224489796 0.585
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 1.825610
iteration 200 / 1500: loss 1.480830
iteration 300 / 1500: loss 1.360206
iteration 400 / 1500: loss 1.478022
iteration 500 / 1500: loss 1.315065
iteration 600 / 1500: loss 1.247591
iteration 700 / 1500: loss 1.234418
iteration 800 / 1500: loss 1.380980
iteration 900 / 1500: loss 1.182532
iteration 1000 / 1500: loss 1.106733
iteration 1100 / 1500: loss 1.216349
iteration 1200 / 1500: loss 1.142483
```

```
iteration 1300 / 1500: loss 1.217735
iteration 1400 / 1500: loss 1.201116
0.3 2e-07 150 1500 0.6227142857142857 0.571
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 1.923236
iteration 200 / 3000: loss 1.405291
iteration 300 / 3000: loss 1.520795
iteration 400 / 3000: loss 1.328728
iteration 500 / 3000: loss 1.313827
iteration 600 / 3000: loss 1.339707
iteration 700 / 3000: loss 1.355101
iteration 800 / 3000: loss 1.221677
iteration 900 / 3000: loss 1.210339
iteration 1000 / 3000: loss 1.281490
iteration 1100 / 3000: loss 1.150248
iteration 1200 / 3000: loss 1.182286
iteration 1300 / 3000: loss 1.270046
iteration 1400 / 3000: loss 1.064207
iteration 1500 / 3000: loss 1.195812
iteration 1600 / 3000: loss 1.081500
iteration 1700 / 3000: loss 1.002393
iteration 1800 / 3000: loss 1.079138
iteration 1900 / 3000: loss 1.019485
iteration 2000 / 3000: loss 1.005818
iteration 2100 / 3000: loss 1.060225
iteration 2200 / 3000: loss 1.071140
iteration 2300 / 3000: loss 1.012516
iteration 2400 / 3000: loss 1.021231
iteration 2500 / 3000: loss 0.827208
iteration 2600 / 3000: loss 0.889679
iteration 2700 / 3000: loss 0.937680
iteration 2800 / 3000: loss 0.904265
iteration 2900 / 3000: loss 0.817346
0.3 2e-07 150 3000 0.6850612244897959 0.579
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 1.857560
iteration 200 / 1500: loss 1.572749
iteration 300 / 1500: loss 1.267005
iteration 400 / 1500: loss 1.354619
iteration 500 / 1500: loss 1.258958
iteration 600 / 1500: loss 1.166776
iteration 700 / 1500: loss 1.230874
iteration 800 / 1500: loss 1.238824
iteration 900 / 1500: loss 1.201996
iteration 1000 / 1500: loss 1.145441
iteration 1100 / 1500: loss 1.084606
iteration 1200 / 1500: loss 1.008969
iteration 1300 / 1500: loss 0.981302
iteration 1400 / 1500: loss 0.996228
0.3 2e-07 175 1500 0.6257959183673469 0.574
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 1.903254
iteration 200 / 3000: loss 1.487875
iteration 300 / 3000: loss 1.355269
iteration 400 / 3000: loss 1.339793
iteration 500 / 3000: loss 1.281435
iteration 600 / 3000: loss 1.255357
iteration 700 / 3000: loss 1.129785
iteration 800 / 3000: loss 1.081565
iteration 900 / 3000: loss 1.254100
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iteration 1000 / 3000: loss 1.138822
iteration 1100 / 3000: loss 1.263180
iteration 1200 / 3000: loss 1.079415
iteration 1300 / 3000: loss 0.975581
iteration 1400 / 3000: loss 0.958881
iteration 1500 / 3000: loss 1.028240
iteration 1600 / 3000: loss 1.039519
iteration 1700 / 3000: loss 1.084825
iteration 1800 / 3000: loss 1.106511
iteration 1900 / 3000: loss 0.983309
iteration 2000 / 3000: loss 1.020936
iteration 2100 / 3000: loss 0.952577
iteration 2200 / 3000: loss 0.955561
iteration 2300 / 3000: loss 1.010738
iteration 2400 / 3000: loss 0.891842
iteration 2500 / 3000: loss 0.871702
iteration 2600 / 3000: loss 0.999913
iteration 2700 / 3000: loss 0.888187
iteration 2800 / 3000: loss 1.022731
iteration 2900 / 3000: loss 0.960904
0.3 2e-07 175 3000 0.6928775510204082 0.59
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 1.914205
iteration 200 / 1500: loss 1.488031
iteration 300 / 1500: loss 1.446658
iteration 400 / 1500: loss 1.182026
iteration 500 / 1500: loss 1.261541
iteration 600 / 1500: loss 1.325419
iteration 700 / 1500: loss 1.345249
iteration 800 / 1500: loss 1.226613
iteration 900 / 1500: loss 1.193734
iteration 1000 / 1500: loss 1.296815
iteration 1100 / 1500: loss 1.259790
iteration 1200 / 1500: loss 1.192646
iteration 1300 / 1500: loss 1.051605
iteration 1400 / 1500: loss 1.090569
0.3 1e-07 100 1500 0.6111836734693877 0.551
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 1.861578
iteration 200 / 3000: loss 1.420475
iteration 300 / 3000: loss 1.437324
iteration 400 / 3000: loss 1.407257
iteration 500 / 3000: loss 1.301119
iteration 600 / 3000: loss 1.259529
iteration 700 / 3000: loss 1.143872
iteration 800 / 3000: loss 1.079263
iteration 900 / 3000: loss 1.073315
iteration 1000 / 3000: loss 1.274614
iteration 1100 / 3000: loss 1.184006
iteration 1200 / 3000: loss 1.109554
iteration 1300 / 3000: loss 1.022257
iteration 1400 / 3000: loss 1.019454
iteration 1500 / 3000: loss 1.184491
iteration 1600 / 3000: loss 1.130063
iteration 1700 / 3000: loss 1.090259
iteration 1800 / 3000: loss 1.064923
iteration 1900 / 3000: loss 0.993765
iteration 2000 / 3000: loss 1.027432
iteration 2100 / 3000: loss 1.057841
iteration 2200 / 3000: loss 0.985762
```

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iteration 2300 / 3000: loss 1.074963
iteration 2400 / 3000: loss 1.102784
iteration 2500 / 3000: loss 0.983353
iteration 2600 / 3000: loss 1.088187
iteration 2700 / 3000: loss 1.023639
iteration 2800 / 3000: loss 1.041927
iteration 2900 / 3000: loss 0.879632
0.3 1e-07 100 3000 0.6611836734693878 0.555
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 1.824135
iteration 200 / 1500: loss 1.436204
iteration 300 / 1500: loss 1.453721
iteration 400 / 1500: loss 1.473710
iteration 500 / 1500: loss 1.478476
iteration 600 / 1500: loss 1.361429
iteration 700 / 1500: loss 1.214201
iteration 800 / 1500: loss 1.207533
iteration 900 / 1500: loss 1.217915
iteration 1000 / 1500: loss 1.131833
iteration 1100 / 1500: loss 1.011908
iteration 1200 / 1500: loss 1.211687
iteration 1300 / 1500: loss 1.083478
iteration 1400 / 1500: loss 0.963578
0.3 1e-07 150 1500 0.6167142857142857 0.576
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 1.818691
iteration 200 / 3000: loss 1.654387
iteration 300 / 3000: loss 1.352701
iteration 400 / 3000: loss 1.372019
iteration 500 / 3000: loss 1.215856
iteration 600 / 3000: loss 1.320398
iteration 700 / 3000: loss 1.231753
iteration 800 / 3000: loss 1.305710
iteration 900 / 3000: loss 1.152225
iteration 1000 / 3000: loss 1.164774
iteration 1100 / 3000: loss 1.239725
iteration 1200 / 3000: loss 1.180680
iteration 1300 / 3000: loss 1.172873
iteration 1400 / 3000: loss 1.103864
iteration 1500 / 3000: loss 1.139673
iteration 1600 / 3000: loss 0.949171
iteration 1700 / 3000: loss 0.955011
iteration 1800 / 3000: loss 0.911333
iteration 1900 / 3000: loss 1.116908
iteration 2000 / 3000: loss 1.103250
iteration 2100 / 3000: loss 1.018802
iteration 2200 / 3000: loss 1.064770
iteration 2300 / 3000: loss 0.968589
iteration 2400 / 3000: loss 0.928128
iteration 2500 / 3000: loss 0.990355
iteration 2600 / 3000: loss 0.987239
iteration 2700 / 3000: loss 1.062059
iteration 2800 / 3000: loss 0.981290
iteration 2900 / 3000: loss 0.892102
0.3 1e-07 150 3000 0.6801428571428572 0.575
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 1.915168
iteration 200 / 1500: loss 1.406389
iteration 300 / 1500: loss 1.233515
iteration 400 / 1500: loss 1.301279
```



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iteration 500 / 1500: loss 1.224305
iteration 600 / 1500: loss 1.292745
iteration 700 / 1500: loss 1.171320
iteration 800 / 1500: loss 1.213119
iteration 900 / 1500: loss 1.230728
iteration 1000 / 1500: loss 1.097455
iteration 1100 / 1500: loss 1.161020
iteration 1200 / 1500: loss 1.148332
iteration 1300 / 1500: loss 1.108262
iteration 1400 / 1500: loss 1.103696
0.3 1e-07 175 1500 0.6268367346938776 0.563
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 1.897716
iteration 200 / 3000: loss 1.552027
iteration 300 / 3000: loss 1.390646
iteration 400 / 3000: loss 1.308007
iteration 500 / 3000: loss 1.230168
iteration 600 / 3000: loss 1.279816
iteration 700 / 3000: loss 1.308391
iteration 800 / 3000: loss 1.173698
iteration 900 / 3000: loss 1.273260
iteration 1000 / 3000: loss 1.165451
iteration 1100 / 3000: loss 1.155267
iteration 1200 / 3000: loss 1.070129
iteration 1300 / 3000: loss 1.145944
iteration 1400 / 3000: loss 1.140940
iteration 1500 / 3000: loss 1.183665
iteration 1600 / 3000: loss 1.100796
iteration 1700 / 3000: loss 1.092760
iteration 1800 / 3000: loss 1.149449
iteration 1900 / 3000: loss 0.951859
iteration 2000 / 3000: loss 1.006551
iteration 2100 / 3000: loss 0.835124
iteration 2200 / 3000: loss 0.898580
iteration 2300 / 3000: loss 0.891952
iteration 2400 / 3000: loss 0.998279
iteration 2500 / 3000: loss 1.117451
iteration 2600 / 3000: loss 1.095574
iteration 2700 / 3000: loss 1.011762
iteration 2800 / 3000: loss 0.947734
iteration 2900 / 3000: loss 0.993534
0.3 1e-07 175 3000 0.6863061224489796 0.592
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 1.889219
iteration 200 / 1500: loss 1.449334
iteration 300 / 1500: loss 1.459348
iteration 400 / 1500: loss 1.374681
iteration 500 / 1500: loss 1.313737
iteration 600 / 1500: loss 1.326432
iteration 700 / 1500: loss 1.382270
iteration 800 / 1500: loss 1.173156
iteration 900 / 1500: loss 1.208045
iteration 1000 / 1500: loss 1.107190
iteration 1100 / 1500: loss 1.263532
iteration 1200 / 1500: loss 1.164127
iteration 1300 / 1500: loss 1.183337
iteration 1400 / 1500: loss 1.077219
0.3 2e-05 100 1500 0.6079591836734693 0.564
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 1.897828
```

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iteration 200 / 3000: loss 1.467057
iteration 300 / 3000: loss 1.395959
iteration 400 / 3000: loss 1.392540
iteration 500 / 3000: loss 1.331435
iteration 600 / 3000: loss 1.271580
iteration 700 / 3000: loss 1.266743
iteration 800 / 3000: loss 1.250985
iteration 900 / 3000: loss 1.280351
iteration 1000 / 3000: loss 1.102922
iteration 1100 / 3000: loss 1.242154
iteration 1200 / 3000: loss 1.358491
iteration 1300 / 3000: loss 1.182420
iteration 1400 / 3000: loss 1.256858
iteration 1500 / 3000: loss 1.223502
iteration 1600 / 3000: loss 1.174015
iteration 1700 / 3000: loss 1.073848
iteration 1800 / 3000: loss 0.985025
iteration 1900 / 3000: loss 1.109320
iteration 2000 / 3000: loss 1.040313
iteration 2100 / 3000: loss 1.035139
iteration 2200 / 3000: loss 1.063179
iteration 2300 / 3000: loss 1.059575
iteration 2400 / 3000: loss 0.957594
iteration 2500 / 3000: loss 0.968469
iteration 2600 / 3000: loss 1.080336
iteration 2700 / 3000: loss 0.986587
iteration 2800 / 3000: loss 0.865402
iteration 2900 / 3000: loss 1.099529
0.3 2e-05 100 3000 0.6579183673469388 0.579
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 1.876340
iteration 200 / 1500: loss 1.464171
iteration 300 / 1500: loss 1.304314
iteration 400 / 1500: loss 1.284944
iteration 500 / 1500: loss 1.276695
iteration 600 / 1500: loss 1.275961
iteration 700 / 1500: loss 1.214174
iteration 800 / 1500: loss 1.171265
iteration 900 / 1500: loss 1.305379
iteration 1000 / 1500: loss 1.229707
iteration 1100 / 1500: loss 1.146509
iteration 1200 / 1500: loss 1.152636
iteration 1300 / 1500: loss 1.087768
iteration 1400 / 1500: loss 1.136095
0.3 2e-05 150 1500 0.6160612244897959 0.563
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 1.938511
iteration 200 / 3000: loss 1.428322
iteration 300 / 3000: loss 1.374366
iteration 400 / 3000: loss 1.402192
iteration 500 / 3000: loss 1.363606
iteration 600 / 3000: loss 1.398350
iteration 700 / 3000: loss 1.223098
iteration 800 / 3000: loss 1.147972
iteration 900 / 3000: loss 1.238309
iteration 1000 / 3000: loss 1.203515
iteration 1100 / 3000: loss 1.074834
iteration 1200 / 3000: loss 1.097596
iteration 1300 / 3000: loss 0.994037
iteration 1400 / 3000: loss 1.036411
```

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iteration 1500 / 3000: loss 1.029644
iteration 1600 / 3000: loss 1.094589
iteration 1700 / 3000: loss 0.905588
iteration 1800 / 3000: loss 1.019745
iteration 1900 / 3000: loss 1.042735
iteration 2000 / 3000: loss 0.979338
iteration 2100 / 3000: loss 1.006893
iteration 2200 / 3000: loss 0.931205
iteration 2300 / 3000: loss 0.968058
iteration 2400 / 3000: loss 0.828188
iteration 2500 / 3000: loss 1.026215
iteration 2600 / 3000: loss 1.086503
iteration 2700 / 3000: loss 0.896616
iteration 2800 / 3000: loss 0.878320
iteration 2900 / 3000: loss 0.985768
0.3 2e-05 150 3000 0.6832857142857143 0.586
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 1.900189
iteration 200 / 1500: loss 1.449862
iteration 300 / 1500: loss 1.386672
iteration 400 / 1500: loss 1.458359
iteration 500 / 1500: loss 1.313744
iteration 600 / 1500: loss 1.167334
iteration 700 / 1500: loss 1.186287
iteration 800 / 1500: loss 1.261683
iteration 900 / 1500: loss 1.260529
iteration 1000 / 1500: loss 1.179343
iteration 1100 / 1500: loss 1.073347
iteration 1200 / 1500: loss 1.040158
iteration 1300 / 1500: loss 1.123835
iteration 1400 / 1500: loss 1.153764
0.3 2e-05 175 1500 0.6233673469387755 0.577
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 1.882834
iteration 200 / 3000: loss 1.345935
iteration 300 / 3000: loss 1.401120
iteration 400 / 3000: loss 1.217637
iteration 500 / 3000: loss 1.287546
iteration 600 / 3000: loss 1.267964
iteration 700 / 3000: loss 1.278788
iteration 800 / 3000: loss 1.187089
iteration 900 / 3000: loss 1.150295
iteration 1000 / 3000: loss 1.190415
iteration 1100 / 3000: loss 1.195944
iteration 1200 / 3000: loss 1.141844
iteration 1300 / 3000: loss 1.230643
iteration 1400 / 3000: loss 1.221038
iteration 1500 / 3000: loss 1.012293
iteration 1600 / 3000: loss 1.025338
iteration 1700 / 3000: loss 1.021385
iteration 1800 / 3000: loss 1.018242
iteration 1900 / 3000: loss 1.017006
iteration 2000 / 3000: loss 0.932952
iteration 2100 / 3000: loss 0.870121
iteration 2200 / 3000: loss 0.975799
iteration 2300 / 3000: loss 0.957460
iteration 2400 / 3000: loss 0.922303
iteration 2500 / 3000: loss 0.926949
iteration 2600 / 3000: loss 0.798439
iteration 2700 / 3000: loss 1.029576
```

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iteration 2800 / 3000: loss 0.922554
iteration 2900 / 3000: loss 0.905369
0.3 2e-05 175 3000 0.6830204081632653 0.58
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302368
iteration 200 / 1500: loss 2.302862
iteration 300 / 1500: loss 2.302603
iteration 400 / 1500: loss 2.302851
iteration 500 / 1500: loss 2.303004
iteration 600 / 1500: loss 2.303145
iteration 700 / 1500: loss 2.302993
iteration 800 / 1500: loss 2.302778
iteration 900 / 1500: loss 2.302412
iteration 1000 / 1500: loss 2.302888
iteration 1100 / 1500: loss 2.302488
iteration 1200 / 1500: loss 2.302207
iteration 1300 / 1500: loss 2.302131
iteration 1400 / 1500: loss 2.302267
0.01 2e-07 100 1500 0.10404081632653062 0.08
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302385
iteration 200 / 3000: loss 2.302665
iteration 300 / 3000: loss 2.302539
iteration 400 / 3000: loss 2.302594
iteration 500 / 3000: loss 2.302518
iteration 600 / 3000: loss 2.302699
iteration 700 / 3000: loss 2.302904
iteration 800 / 3000: loss 2.302663
iteration 900 / 3000: loss 2.302749
iteration 1000 / 3000: loss 2.303077
iteration 1100 / 3000: loss 2.303139
iteration 1200 / 3000: loss 2.302096
iteration 1300 / 3000: loss 2.303164
iteration 1400 / 3000: loss 2.302028
iteration 1500 / 3000: loss 2.302835
iteration 1600 / 3000: loss 2.301581
iteration 1700 / 3000: loss 2.301586
iteration 1800 / 3000: loss 2.299801
iteration 1900 / 3000: loss 2.297119
iteration 2000 / 3000: loss 2.295164
iteration 2100 / 3000: loss 2.291991
iteration 2200 / 3000: loss 2.285401
iteration 2300 / 3000: loss 2.274336
iteration 2400 / 3000: loss 2.263266
iteration 2500 / 3000: loss 2.258734
iteration 2600 / 3000: loss 2.220088
iteration 2700 / 3000: loss 2.160037
iteration 2800 / 3000: loss 2.162099
iteration 2900 / 3000: loss 2.169093
0.01 2e-07 100 3000 0.22542857142857142 0.229
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302540
iteration 200 / 1500: loss 2.302596
iteration 300 / 1500: loss 2.302595
iteration 400 / 1500: loss 2.302602
iteration 500 / 1500: loss 2.302839
iteration 600 / 1500: loss 2.302399
iteration 700 / 1500: loss 2.302638
iteration 800 / 1500: loss 2.302492
iteration 900 / 1500: loss 2.302391
```

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iteration 1000 / 1500: loss 2.302188
iteration 1100 / 1500: loss 2.302269
iteration 1200 / 1500: loss 2.302604
iteration 1300 / 1500: loss 2.301440
iteration 1400 / 1500: loss 2.301645
0.01 2e-07 150 1500 0.09973469387755102 0.113
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302563
iteration 200 / 3000: loss 2.302631
iteration 300 / 3000: loss 2.302477
iteration 400 / 3000: loss 2.302772
iteration 500 / 3000: loss 2.302506
iteration 600 / 3000: loss 2.302655
iteration 700 / 3000: loss 2.302647
iteration 800 / 3000: loss 2.302432
iteration 900 / 3000: loss 2.302394
iteration 1000 / 3000: loss 2.302795
iteration 1100 / 3000: loss 2.302198
iteration 1200 / 3000: loss 2.302038
iteration 1300 / 3000: loss 2.302742
iteration 1400 / 3000: loss 2.301864
iteration 1500 / 3000: loss 2.301677
iteration 1600 / 3000: loss 2.299826
iteration 1700 / 3000: loss 2.298890
iteration 1800 / 3000: loss 2.296451
iteration 1900 / 3000: loss 2.293659
iteration 2000 / 3000: loss 2.286151
iteration 2100 / 3000: loss 2.274136
iteration 2200 / 3000: loss 2.267897
iteration 2300 / 3000: loss 2.258705
iteration 2400 / 3000: loss 2.234010
iteration 2500 / 3000: loss 2.219267
iteration 2600 / 3000: loss 2.222774
iteration 2700 / 3000: loss 2.162052
iteration 2800 / 3000: loss 2.145215
iteration 2900 / 3000: loss 2.097989
0.01 2e-07 150 3000 0.22053061224489795 0.227
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302712
iteration 200 / 1500: loss 2.302499
iteration 300 / 1500: loss 2.302624
iteration 400 / 1500: loss 2.302353
iteration 500 / 1500: loss 2.302877
iteration 600 / 1500: loss 2.302841
iteration 700 / 1500: loss 2.302409
iteration 800 / 1500: loss 2.302593
iteration 900 / 1500: loss 2.302764
iteration 1000 / 1500: loss 2.302312
iteration 1100 / 1500: loss 2.302225
iteration 1200 / 1500: loss 2.302077
iteration 1300 / 1500: loss 2.302521
iteration 1400 / 1500: loss 2.301736
0.01 2e-07 175 1500 0.16438775510204082 0.137
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302372
iteration 200 / 3000: loss 2.302878
iteration 300 / 3000: loss 2.302751
iteration 400 / 3000: loss 2.302939
iteration 500 / 3000: loss 2.302657
iteration 600 / 3000: loss 2.302907
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iteration 700 / 3000: loss 2.302776
iteration 800 / 3000: loss 2.302607
iteration 900 / 3000: loss 2.301990
iteration 1000 / 3000: loss 2.302340
iteration 1100 / 3000: loss 2.302366
iteration 1200 / 3000: loss 2.302131
iteration 1300 / 3000: loss 2.302303
iteration 1400 / 3000: loss 2.301259
iteration 1500 / 3000: loss 2.301075
iteration 1600 / 3000: loss 2.300169
iteration 1700 / 3000: loss 2.297560
iteration 1800 / 3000: loss 2.292704
iteration 1900 / 3000: loss 2.289782
iteration 2000 / 3000: loss 2.282547
iteration 2100 / 3000: loss 2.278380
iteration 2200 / 3000: loss 2.263431
iteration 2300 / 3000: loss 2.228548
iteration 2400 / 3000: loss 2.226201
iteration 2500 / 3000: loss 2.171598
iteration 2600 / 3000: loss 2.194760
iteration 2700 / 3000: loss 2.184700
iteration 2800 / 3000: loss 2.101624
iteration 2900 / 3000: loss 2.104112
0.01 2e-07 175 3000 0.22610204081632654 0.238
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302644
iteration 200 / 1500: loss 2.302478
iteration 300 / 1500: loss 2.302388
iteration 400 / 1500: loss 2.302529
iteration 500 / 1500: loss 2.302468
iteration 600 / 1500: loss 2.302544
iteration 700 / 1500: loss 2.302569
iteration 800 / 1500: loss 2.302753
iteration 900 / 1500: loss 2.302768
iteration 1000 / 1500: loss 2.302321
iteration 1100 / 1500: loss 2.302215
iteration 1200 / 1500: loss 2.302138
iteration 1300 / 1500: loss 2.301607
iteration 1400 / 1500: loss 2.301439
0.01 1e-07 100 1500 0.1070204081632653 0.102
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302703
iteration 200 / 3000: loss 2.302399
iteration 300 / 3000: loss 2.302826
iteration 400 / 3000: loss 2.302619
iteration 500 / 3000: loss 2.302652
iteration 600 / 3000: loss 2.302965
iteration 700 / 3000: loss 2.302807
iteration 800 / 3000: loss 2.302518
iteration 900 / 3000: loss 2.302443
iteration 1000 / 3000: loss 2.302669
iteration 1100 / 3000: loss 2.302155
iteration 1200 / 3000: loss 2.302319
iteration 1300 / 3000: loss 2.302065
iteration 1400 / 3000: loss 2.302032
iteration 1500 / 3000: loss 2.301116
iteration 1600 / 3000: loss 2.300535
iteration 1700 / 3000: loss 2.300073
iteration 1800 / 3000: loss 2.297418
iteration 1900 / 3000: loss 2.293003
```

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iteration 2000 / 3000: loss 2.294170
iteration 2100 / 3000: loss 2.281406
iteration 2200 / 3000: loss 2.270719
iteration 2300 / 3000: loss 2.257893
iteration 2400 / 3000: loss 2.237729
iteration 2500 / 3000: loss 2.194151
iteration 2600 / 3000: loss 2.200797
iteration 2700 / 3000: loss 2.188218
iteration 2800 / 3000: loss 2.194815
iteration 2900 / 3000: loss 2.120827
0.01 1e-07 100 3000 0.23751020408163265 0.24
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302671
iteration 200 / 1500: loss 2.302384
iteration 300 / 1500: loss 2.302482
iteration 400 / 1500: loss 2.301626
iteration 500 / 1500: loss 2.302649
iteration 600 / 1500: loss 2.302525
iteration 700 / 1500: loss 2.302765
iteration 800 / 1500: loss 2.302801
iteration 900 / 1500: loss 2.302926
iteration 1000 / 1500: loss 2.302169
iteration 1100 / 1500: loss 2.302026
iteration 1200 / 1500: loss 2.302011
iteration 1300 / 1500: loss 2.302523
iteration 1400 / 1500: loss 2.301994
0.01 1e-07 150 1500 0.1466938775510204 0.136
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302607
iteration 200 / 3000: loss 2.302527
iteration 300 / 3000: loss 2.302969
iteration 400 / 3000: loss 2.302510
iteration 500 / 3000: loss 2.302596
iteration 600 / 3000: loss 2.302503
iteration 700 / 3000: loss 2.302206
iteration 800 / 3000: loss 2.302721
iteration 900 / 3000: loss 2.302597
iteration 1000 / 3000: loss 2.302324
iteration 1100 / 3000: loss 2.302197
iteration 1200 / 3000: loss 2.302448
iteration 1300 / 3000: loss 2.302359
iteration 1400 / 3000: loss 2.301896
iteration 1500 / 3000: loss 2.300958
iteration 1600 / 3000: loss 2.300187
iteration 1700 / 3000: loss 2.300165
iteration 1800 / 3000: loss 2.298185
iteration 1900 / 3000: loss 2.291383
iteration 2000 / 3000: loss 2.284457
iteration 2100 / 3000: loss 2.273926
iteration 2200 / 3000: loss 2.266884
iteration 2300 / 3000: loss 2.250609
iteration 2400 / 3000: loss 2.228279
iteration 2500 / 3000: loss 2.204118
iteration 2600 / 3000: loss 2.212226
iteration 2700 / 3000: loss 2.154979
iteration 2800 / 3000: loss 2.122800
iteration 2900 / 3000: loss 2.097730
0.01 1e-07 150 3000 0.22844897959183674 0.237
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302739
```

```
iteration 200 / 1500: loss 2.302319
iteration 300 / 1500: loss 2.302449
iteration 400 / 1500: loss 2.302542
iteration 500 / 1500: loss 2.302447
iteration 600 / 1500: loss 2.302920
iteration 700 / 1500: loss 2.302200
iteration 800 / 1500: loss 2.302850
iteration 900 / 1500: loss 2.302698
iteration 1000 / 1500: loss 2.302572
iteration 1100 / 1500: loss 2.302235
iteration 1200 / 1500: loss 2.301657
iteration 1300 / 1500: loss 2.301871
iteration 1400 / 1500: loss 2.301647
0.01 1e-07 175 1500 0.15210204081632653 0.123
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302565
iteration 200 / 3000: loss 2.302949
iteration 300 / 3000: loss 2.302270
iteration 400 / 3000: loss 2.302519
iteration 500 / 3000: loss 2.301678
iteration 600 / 3000: loss 2.302605
iteration 700 / 3000: loss 2.302892
iteration 800 / 3000: loss 2.303030
iteration 900 / 3000: loss 2.302206
iteration 1000 / 3000: loss 2.302667
iteration 1100 / 3000: loss 2.302402
iteration 1200 / 3000: loss 2.301703
iteration 1300 / 3000: loss 2.301596
iteration 1400 / 3000: loss 2.301610
iteration 1500 / 3000: loss 2.301427
iteration 1600 / 3000: loss 2.299857
iteration 1700 / 3000: loss 2.297366
iteration 1800 / 3000: loss 2.294597
iteration 1900 / 3000: loss 2.286632
iteration 2000 / 3000: loss 2.283065
iteration 2100 / 3000: loss 2.261999
iteration 2200 / 3000: loss 2.252287
iteration 2300 / 3000: loss 2.219027
iteration 2400 / 3000: loss 2.229507
iteration 2500 / 3000: loss 2.223188
iteration 2600 / 3000: loss 2.199199
iteration 2700 / 3000: loss 2.159499
iteration 2800 / 3000: loss 2.123331
iteration 2900 / 3000: loss 2.099282
0.01 1e-07 175 3000 0.22853061224489796 0.238
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302442
iteration 200 / 1500: loss 2.302642
iteration 300 / 1500: loss 2.302479
iteration 400 / 1500: loss 2.302237
iteration 500 / 1500: loss 2.302822
iteration 600 / 1500: loss 2.302235
iteration 700 / 1500: loss 2.302426
iteration 800 / 1500: loss 2.302163
iteration 900 / 1500: loss 2.302943
iteration 1000 / 1500: loss 2.302986
iteration 1100 / 1500: loss 2.302309
iteration 1200 / 1500: loss 2.302039
iteration 1300 / 1500: loss 2.302187
iteration 1400 / 1500: loss 2.301045
```



0.01 2e-05 100 1500 0.14420408163265305 0.114

iteration 0 / 3000: loss 2.302585

iteration 100 / 3000: loss 2.302538

iteration 200 / 3000: loss 2.302608

iteration 300 / 3000: loss 2.302563

iteration 400 / 3000: loss 2.302659

iteration 500 / 3000: loss 2.302384

iteration 600 / 3000: loss 2.302592

iteration 700 / 3000: loss 2.302677

iteration 800 / 3000: loss 2.302580

iteration 900 / 3000: loss 2.302607

iteration 1000 / 3000: loss 2.302196

iteration 1100 / 3000: loss 2.302608

iteration 1200 / 3000: loss 2.302411

iteration 1300 / 3000: loss 2.302046

iteration 1400 / 3000: loss 2.301888

iteration 1500 / 3000: loss 2.301288

iteration 1600 / 3000: loss 2.300899

iteration 1700 / 3000: loss 2.299483

iteration 1800 / 3000: loss 2.298019

iteration 1900 / 3000: loss 2.294437

iteration 2000 / 3000: loss 2.288907

iteration 2100 / 3000: loss 2.282757

iteration 2200 / 3000: loss 2.274444

iteration 2300 / 3000: loss 2.255691

iteration 2400 / 3000: loss 2.226529

iteration 2500 / 3000: loss 2.216729

iteration 2600 / 3000: loss 2.219719

iteration 2700 / 3000: loss 2.173546

iteration 2800 / 3000: loss 2.129247

iteration 2900 / 3000: loss 2.164320

0.01 2e-05 100 3000 0.2257142857142857 0.231

iteration 0 / 1500: loss 2.302585

iteration 100 / 1500: loss 2.302590

iteration 200 / 1500: loss 2.302669

iteration 300 / 1500: loss 2.302881

iteration 400 / 1500: loss 2.302754

iteration 500 / 1500: loss 2.302584

iteration 600 / 1500: loss 2.302606

iteration 700 / 1500: loss 2.302535

iteration 800 / 1500: loss 2.302563

iteration 900 / 1500: loss 2.302261

iteration 1000 / 1500: loss 2.302769

iteration 1100 / 1500: loss 2.302256

iteration 1200 / 1500: loss 2.302271

iteration 1300 / 1500: loss 2.302136

iteration 1400 / 1500: loss 2.301716

0.01 2e-05 150 1500 0.18193877551020407 0.201

iteration 0 / 3000: loss 2.302585

iteration 100 / 3000: loss 2.302464

iteration 200 / 3000: loss 2.302680

iteration 300 / 3000: loss 2.302705

iteration 400 / 3000: loss 2.302140

iteration 500 / 3000: loss 2.302290

iteration 600 / 3000: loss 2.302594

iteration 700 / 3000: loss 2.302060

iteration 800 / 3000: loss 2.302608

iteration 900 / 3000: loss 2.301997

iteration 1000 / 3000: loss 2.301984

iteration 1100 / 3000: loss 2.302805

```
iteration 1200 / 3000: loss 2.302528
iteration 1300 / 3000: loss 2.301978
iteration 1400 / 3000: loss 2.301621
iteration 1500 / 3000: loss 2.301262
iteration 1600 / 3000: loss 2.299780
iteration 1700 / 3000: loss 2.298482
iteration 1800 / 3000: loss 2.297186
iteration 1900 / 3000: loss 2.291540
iteration 2000 / 3000: loss 2.286660
iteration 2100 / 3000: loss 2.276794
iteration 2200 / 3000: loss 2.274018
iteration 2300 / 3000: loss 2.236958
iteration 2400 / 3000: loss 2.219090
iteration 2500 / 3000: loss 2.187036
iteration 2600 / 3000: loss 2.197137
iteration 2700 / 3000: loss 2.159185
iteration 2800 / 3000: loss 2.123648
iteration 2900 / 3000: loss 2.154456
0.01 2e-05 150 3000 0.22646938775510203 0.236
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302417
iteration 200 / 1500: loss 2.302522
iteration 300 / 1500: loss 2.302280
iteration 400 / 1500: loss 2.302275
iteration 500 / 1500: loss 2.303152
iteration 600 / 1500: loss 2.302241
iteration 700 / 1500: loss 2.302172
iteration 800 / 1500: loss 2.302780
iteration 900 / 1500: loss 2.302562
iteration 1000 / 1500: loss 2.302184
iteration 1100 / 1500: loss 2.302570
iteration 1200 / 1500: loss 2.302123
iteration 1300 / 1500: loss 2.301957
iteration 1400 / 1500: loss 2.301381
0.01 2e-05 175 1500 0.10026530612244898 0.087
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302693
iteration 200 / 3000: loss 2.302444
iteration 300 / 3000: loss 2.302715
iteration 400 / 3000: loss 2.302563
iteration 500 / 3000: loss 2.302223
iteration 600 / 3000: loss 2.302527
iteration 700 / 3000: loss 2.302216
iteration 800 / 3000: loss 2.302796
iteration 900 / 3000: loss 2.301881
iteration 1000 / 3000: loss 2.302430
iteration 1100 / 3000: loss 2.302662
iteration 1200 / 3000: loss 2.302348
iteration 1300 / 3000: loss 2.302231
iteration 1400 / 3000: loss 2.301804
iteration 1500 / 3000: loss 2.301310
iteration 1600 / 3000: loss 2.300744
iteration 1700 / 3000: loss 2.298646
iteration 1800 / 3000: loss 2.295363
iteration 1900 / 3000: loss 2.292592
iteration 2000 / 3000: loss 2.285332
iteration 2100 / 3000: loss 2.278908
iteration 2200 / 3000: loss 2.266085
iteration 2300 / 3000: loss 2.260659
iteration 2400 / 3000: loss 2.252183
```

```
iteration 2500 / 3000: loss 2.214742
iteration 2600 / 3000: loss 2.145333
iteration 2700 / 3000: loss 2.179101
iteration 2800 / 3000: loss 2.140991
iteration 2900 / 3000: loss 2.153157
0.01 2e-05 175 3000 0.23173469387755102 0.255
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302598
iteration 200 / 1500: loss 2.302633
iteration 300 / 1500: loss 2.302686
iteration 400 / 1500: loss 2.302631
iteration 500 / 1500: loss 2.302598
iteration 600 / 1500: loss 2.302514
iteration 700 / 1500: loss 2.302789
iteration 800 / 1500: loss 2.302664
iteration 900 / 1500: loss 2.302579
iteration 1000 / 1500: loss 2.302507
iteration 1100 / 1500: loss 2.302752
iteration 1200 / 1500: loss 2.302552
iteration 1300 / 1500: loss 2.302490
iteration 1400 / 1500: loss 2.302505
0.002 2e-07 100 1500 0.09985714285714285 0.107
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302579
iteration 200 / 3000: loss 2.302575
iteration 300 / 3000: loss 2.302496
iteration 400 / 3000: loss 2.302408
iteration 500 / 3000: loss 2.302436
iteration 600 / 3000: loss 2.302518
iteration 700 / 3000: loss 2.302472
iteration 800 / 3000: loss 2.302752
iteration 900 / 3000: loss 2.302604
iteration 1000 / 3000: loss 2.302600
iteration 1100 / 3000: loss 2.302580
iteration 1200 / 3000: loss 2.302732
iteration 1300 / 3000: loss 2.302572
iteration 1400 / 3000: loss 2.302624
iteration 1500 / 3000: loss 2.302704
iteration 1600 / 3000: loss 2.302743
iteration 1700 / 3000: loss 2.302557
iteration 1800 / 3000: loss 2.302759
iteration 1900 / 3000: loss 2.302641
iteration 2000 / 3000: loss 2.302648
iteration 2100 / 3000: loss 2.302766
iteration 2200 / 3000: loss 2.302628
iteration 2300 / 3000: loss 2.302586
iteration 2400 / 3000: loss 2.302570
iteration 2500 / 3000: loss 2.302693
iteration 2600 / 3000: loss 2.302557
iteration 2700 / 3000: loss 2.302556
iteration 2800 / 3000: loss 2.302496
iteration 2900 / 3000: loss 2.302458
0.002 2e-07 100 3000 0.10004081632653061 0.098
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302588
iteration 200 / 1500: loss 2.302496
iteration 300 / 1500: loss 2.302537
iteration 400 / 1500: loss 2.302579
iteration 500 / 1500: loss 2.302557
iteration 600 / 1500: loss 2.302507
```

```
iteration 700 / 1500: loss 2.302604
iteration 800 / 1500: loss 2.302646
iteration 900 / 1500: loss 2.302490
iteration 1000 / 1500: loss 2.302423
iteration 1100 / 1500: loss 2.302663
iteration 1200 / 1500: loss 2.302497
iteration 1300 / 1500: loss 2.302672
iteration 1400 / 1500: loss 2.302370
0.002 2e-07 150 1500 0.10044897959183674 0.078
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302579
iteration 200 / 3000: loss 2.302596
iteration 300 / 3000: loss 2.302467
iteration 400 / 3000: loss 2.302614
iteration 500 / 3000: loss 2.302534
iteration 600 / 3000: loss 2.302573
iteration 700 / 3000: loss 2.302641
iteration 800 / 3000: loss 2.302703
iteration 900 / 3000: loss 2.302621
iteration 1000 / 3000: loss 2.302544
iteration 1100 / 3000: loss 2.302563
iteration 1200 / 3000: loss 2.302517
iteration 1300 / 3000: loss 2.302529
iteration 1400 / 3000: loss 2.302607
iteration 1500 / 3000: loss 2.302554
iteration 1600 / 3000: loss 2.302661
iteration 1700 / 3000: loss 2.302581
iteration 1800 / 3000: loss 2.302563
iteration 1900 / 3000: loss 2.302562
iteration 2000 / 3000: loss 2.302551
iteration 2100 / 3000: loss 2.302514
iteration 2200 / 3000: loss 2.302467
iteration 2300 / 3000: loss 2.302622
iteration 2400 / 3000: loss 2.302478
iteration 2500 / 3000: loss 2.302706
iteration 2600 / 3000: loss 2.302542
iteration 2700 / 3000: loss 2.302449
iteration 2800 / 3000: loss 2.302618
iteration 2900 / 3000: loss 2.302611
0.002 2e-07 150 3000 0.10044897959183674 0.078
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302589
iteration 200 / 1500: loss 2.302597
iteration 300 / 1500: loss 2.302553
iteration 400 / 1500: loss 2.302659
iteration 500 / 1500: loss 2.302710
iteration 600 / 1500: loss 2.302721
iteration 700 / 1500: loss 2.302615
iteration 800 / 1500: loss 2.302544
iteration 900 / 1500: loss 2.302553
iteration 1000 / 1500: loss 2.302593
iteration 1100 / 1500: loss 2.302596
iteration 1200 / 1500: loss 2.302605
iteration 1300 / 1500: loss 2.302567
iteration 1400 / 1500: loss 2.302612
0.002 2e-07 175 1500 0.10004081632653061 0.098
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302597
iteration 200 / 3000: loss 2.302583
iteration 300 / 3000: loss 2.302671
```

```
iteration 400 / 3000: loss 2.302533
iteration 500 / 3000: loss 2.302603
iteration 600 / 3000: loss 2.302617
iteration 700 / 3000: loss 2.302582
iteration 800 / 3000: loss 2.302616
iteration 900 / 3000: loss 2.302623
iteration 1000 / 3000: loss 2.302487
iteration 1100 / 3000: loss 2.302506
iteration 1200 / 3000: loss 2.302589
iteration 1300 / 3000: loss 2.302561
iteration 1400 / 3000: loss 2.302524
iteration 1500 / 3000: loss 2.302663
iteration 1600 / 3000: loss 2.302599
iteration 1700 / 3000: loss 2.302477
iteration 1800 / 3000: loss 2.302498
iteration 1900 / 3000: loss 2.302489
iteration 2000 / 3000: loss 2.302415
iteration 2100 / 3000: loss 2.302623
iteration 2200 / 3000: loss 2.302620
iteration 2300 / 3000: loss 2.302544
iteration 2400 / 3000: loss 2.302818
iteration 2500 / 3000: loss 2.302699
iteration 2600 / 3000: loss 2.302597
iteration 2700 / 3000: loss 2.302661
iteration 2800 / 3000: loss 2.302787
iteration 2900 / 3000: loss 2.302555
0.002 2e-07 175 3000 0.10042857142857142 0.079
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302615
iteration 200 / 1500: loss 2.302602
iteration 300 / 1500: loss 2.302554
iteration 400 / 1500: loss 2.302594
iteration 500 / 1500: loss 2.302588
iteration 600 / 1500: loss 2.302597
iteration 700 / 1500: loss 2.302612
iteration 800 / 1500: loss 2.302725
iteration 900 / 1500: loss 2.302512
iteration 1000 / 1500: loss 2.302500
iteration 1100 / 1500: loss 2.302682
iteration 1200 / 1500: loss 2.302623
iteration 1300 / 1500: loss 2.302530
iteration 1400 / 1500: loss 2.302615
0.002 1e-07 100 1500 0.10026530612244898 0.087
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302594
iteration 200 / 3000: loss 2.302584
iteration 300 / 3000: loss 2.302602
iteration 400 / 3000: loss 2.302587
iteration 500 / 3000: loss 2.302636
iteration 600 / 3000: loss 2.302575
iteration 700 / 3000: loss 2.302645
iteration 800 / 3000: loss 2.302553
iteration 900 / 3000: loss 2.302697
iteration 1000 / 3000: loss 2.302674
iteration 1100 / 3000: loss 2.302590
iteration 1200 / 3000: loss 2.302633
iteration 1300 / 3000: loss 2.302619
iteration 1400 / 3000: loss 2.302499
iteration 1500 / 3000: loss 2.302598
iteration 1600 / 3000: loss 2.302629
```

```
iteration 1700 / 3000: loss 2.302622
iteration 1800 / 3000: loss 2.302624
iteration 1900 / 3000: loss 2.302539
iteration 2000 / 3000: loss 2.302532
iteration 2100 / 3000: loss 2.302595
iteration 2200 / 3000: loss 2.302503
iteration 2300 / 3000: loss 2.302622
iteration 2400 / 3000: loss 2.302468
iteration 2500 / 3000: loss 2.302413
iteration 2600 / 3000: loss 2.302551
iteration 2700 / 3000: loss 2.302616
iteration 2800 / 3000: loss 2.302598
iteration 2900 / 3000: loss 2.302543
0.002 1e-07 100 3000 0.10044897959183674 0.078
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302642
iteration 200 / 1500: loss 2.302588
iteration 300 / 1500: loss 2.302567
iteration 400 / 1500: loss 2.302566
iteration 500 / 1500: loss 2.302675
iteration 600 / 1500: loss 2.302394
iteration 700 / 1500: loss 2.302549
iteration 800 / 1500: loss 2.302631
iteration 900 / 1500: loss 2.302534
iteration 1000 / 1500: loss 2.302519
iteration 1100 / 1500: loss 2.302509
iteration 1200 / 1500: loss 2.302641
iteration 1300 / 1500: loss 2.302715
iteration 1400 / 1500: loss 2.302517
0.002 1e-07 150 1500 0.10042857142857142 0.079
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302533
iteration 200 / 3000: loss 2.302635
iteration 300 / 3000: loss 2.302541
iteration 400 / 3000: loss 2.302550
iteration 500 / 3000: loss 2.302608
iteration 600 / 3000: loss 2.302529
iteration 700 / 3000: loss 2.302490
iteration 800 / 3000: loss 2.302635
iteration 900 / 3000: loss 2.302563
iteration 1000 / 3000: loss 2.302611
iteration 1100 / 3000: loss 2.302656
iteration 1200 / 3000: loss 2.302471
iteration 1300 / 3000: loss 2.302592
iteration 1400 / 3000: loss 2.302592
iteration 1500 / 3000: loss 2.302543
iteration 1600 / 3000: loss 2.302757
iteration 1700 / 3000: loss 2.302626
iteration 1800 / 3000: loss 2.302368
iteration 1900 / 3000: loss 2.302462
iteration 2000 / 3000: loss 2.302676
iteration 2100 / 3000: loss 2.302615
iteration 2200 / 3000: loss 2.302693
iteration 2300 / 3000: loss 2.302603
iteration 2400 / 3000: loss 2.302740
iteration 2500 / 3000: loss 2.302679
iteration 2600 / 3000: loss 2.302763
iteration 2700 / 3000: loss 2.302647
iteration 2800 / 3000: loss 2.302581
iteration 2900 / 3000: loss 2.302335
```

0.002 1e-07 150 3000 0.10042857142857142 0.079

iteration 0 / 1500: loss 2.302585

iteration 100 / 1500: loss 2.302603

iteration 200 / 1500: loss 2.302597

iteration 300 / 1500: loss 2.302547

iteration 400 / 1500: loss 2.302540

iteration 500 / 1500: loss 2.302520

iteration 600 / 1500: loss 2.302701

iteration 700 / 1500: loss 2.302650

iteration 800 / 1500: loss 2.302689

iteration 900 / 1500: loss 2.302506

iteration 1000 / 1500: loss 2.302701

iteration 1100 / 1500: loss 2.302623

iteration 1200 / 1500: loss 2.302350

iteration 1300 / 1500: loss 2.302557

iteration 1400 / 1500: loss 2.302481

0.002 1e-07 175 1500 0.10042857142857142 0.079

iteration 0 / 3000: loss 2.302585

iteration 100 / 3000: loss 2.302570

iteration 200 / 3000: loss 2.302630

iteration 300 / 3000: loss 2.302594

iteration 400 / 3000: loss 2.302570

iteration 500 / 3000: loss 2.302643

iteration 600 / 3000: loss 2.302646

iteration 700 / 3000: loss 2.302613

iteration 800 / 3000: loss 2.302608

iteration 900 / 3000: loss 2.302604

iteration 1000 / 3000: loss 2.302671

iteration 1100 / 3000: loss 2.302721

iteration 1200 / 3000: loss 2.302441

iteration 1300 / 3000: loss 2.302680

iteration 1400 / 3000: loss 2.302514

iteration 1500 / 3000: loss 2.302565

iteration 1600 / 3000: loss 2.302696

iteration 1700 / 3000: loss 2.302617

iteration 1800 / 3000: loss 2.302794

iteration 1900 / 3000: loss 2.302595

iteration 2000 / 3000: loss 2.302544

iteration 2100 / 3000: loss 2.302607

iteration 2200 / 3000: loss 2.302527

iteration 2300 / 3000: loss 2.302755

iteration 2400 / 3000: loss 2.302579

iteration 2500 / 3000: loss 2.302476

iteration 2600 / 3000: loss 2.302660

iteration 2700 / 3000: loss 2.302676

iteration 2800 / 3000: loss 2.302607

iteration 2900 / 3000: loss 2.302570

0.002 1e-07 175 3000 0.10026530612244898 0.087

iteration 0 / 1500: loss 2.302585

iteration 100 / 1500: loss 2.302591

iteration 200 / 1500: loss 2.302597

iteration 300 / 1500: loss 2.302583

iteration 400 / 1500: loss 2.302533

iteration 500 / 1500: loss 2.302484

iteration 600 / 1500: loss 2.302482

iteration 700 / 1500: loss 2.302593

iteration 800 / 1500: loss 2.302693

iteration 900 / 1500: loss 2.302502

iteration 1000 / 1500: loss 2.302777

iteration 1100 / 1500: loss 2.302601

```
iteration 1200 / 1500: loss 2.302549
iteration 1300 / 1500: loss 2.302636
iteration 1400 / 1500: loss 2.302662
0.002 2e-05 100 1500 0.10042857142857142 0.079
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302579
iteration 200 / 3000: loss 2.302597
iteration 300 / 3000: loss 2.302641
iteration 400 / 3000: loss 2.302533
iteration 500 / 3000: loss 2.302470
iteration 600 / 3000: loss 2.302508
iteration 700 / 3000: loss 2.302558
iteration 800 / 3000: loss 2.302607
iteration 900 / 3000: loss 2.302523
iteration 1000 / 3000: loss 2.302558
iteration 1100 / 3000: loss 2.302545
iteration 1200 / 3000: loss 2.302477
iteration 1300 / 3000: loss 2.302635
iteration 1400 / 3000: loss 2.302544
iteration 1500 / 3000: loss 2.302573
iteration 1600 / 3000: loss 2.302606
iteration 1700 / 3000: loss 2.302544
iteration 1800 / 3000: loss 2.302621
iteration 1900 / 3000: loss 2.302547
iteration 2000 / 3000: loss 2.302579
iteration 2100 / 3000: loss 2.302634
iteration 2200 / 3000: loss 2.302504
iteration 2300 / 3000: loss 2.302654
iteration 2400 / 3000: loss 2.302525
iteration 2500 / 3000: loss 2.302428
iteration 2600 / 3000: loss 2.302682
iteration 2700 / 3000: loss 2.302359
iteration 2800 / 3000: loss 2.302484
iteration 2900 / 3000: loss 2.302696
0.002 2e-05 100 3000 0.10042857142857142 0.079
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302532
iteration 200 / 1500: loss 2.302548
iteration 300 / 1500: loss 2.302577
iteration 400 / 1500: loss 2.302604
iteration 500 / 1500: loss 2.302627
iteration 600 / 1500: loss 2.302595
iteration 700 / 1500: loss 2.302599
iteration 800 / 1500: loss 2.302627
iteration 900 / 1500: loss 2.302574
iteration 1000 / 1500: loss 2.302630
iteration 1100 / 1500: loss 2.302559
iteration 1200 / 1500: loss 2.302564
iteration 1300 / 1500: loss 2.302619
iteration 1400 / 1500: loss 2.302538
0.002 2e-05 150 1500 0.09985714285714285 0.107
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302601
iteration 200 / 3000: loss 2.302580
iteration 300 / 3000: loss 2.302550
iteration 400 / 3000: loss 2.302628
iteration 500 / 3000: loss 2.302581
iteration 600 / 3000: loss 2.302602
iteration 700 / 3000: loss 2.302615
iteration 800 / 3000: loss 2.302612
```



```
iteration 900 / 3000: loss 2.302533
iteration 1000 / 3000: loss 2.302445
iteration 1100 / 3000: loss 2.302469
iteration 1200 / 3000: loss 2.302497
iteration 1300 / 3000: loss 2.302539
iteration 1400 / 3000: loss 2.302647
iteration 1500 / 3000: loss 2.302631
iteration 1600 / 3000: loss 2.302613
iteration 1700 / 3000: loss 2.302610
iteration 1800 / 3000: loss 2.302764
iteration 1900 / 3000: loss 2.302512
iteration 2000 / 3000: loss 2.302595
iteration 2100 / 3000: loss 2.302700
iteration 2200 / 3000: loss 2.302373
iteration 2300 / 3000: loss 2.302648
iteration 2400 / 3000: loss 2.302673
iteration 2500 / 3000: loss 2.302463
iteration 2600 / 3000: loss 2.302557
iteration 2700 / 3000: loss 2.302611
iteration 2800 / 3000: loss 2.302531
iteration 2900 / 3000: loss 2.302550
0.002 2e-05 150 3000 0.10044897959183674 0.078
iteration 0 / 1500: loss 2.302585
iteration 100 / 1500: loss 2.302608
iteration 200 / 1500: loss 2.302597
iteration 300 / 1500: loss 2.302553
iteration 400 / 1500: loss 2.302422
iteration 500 / 1500: loss 2.302544
iteration 600 / 1500: loss 2.302437
iteration 700 / 1500: loss 2.302565
iteration 800 / 1500: loss 2.302633
iteration 900 / 1500: loss 2.302391
iteration 1000 / 1500: loss 2.302695
iteration 1100 / 1500: loss 2.302614
iteration 1200 / 1500: loss 2.302506
iteration 1300 / 1500: loss 2.302456
iteration 1400 / 1500: loss 2.302767
0.002 2e-05 175 1500 0.09973469387755102 0.113
iteration 0 / 3000: loss 2.302585
iteration 100 / 3000: loss 2.302632
iteration 200 / 3000: loss 2.302558
iteration 300 / 3000: loss 2.302522
iteration 400 / 3000: loss 2.302640
iteration 500 / 3000: loss 2.302658
iteration 600 / 3000: loss 2.302640
iteration 700 / 3000: loss 2.302646
iteration 800 / 3000: loss 2.302487
iteration 900 / 3000: loss 2.302505
iteration 1000 / 3000: loss 2.302634
iteration 1100 / 3000: loss 2.302687
iteration 1200 / 3000: loss 2.302752
iteration 1300 / 3000: loss 2.302464
iteration 1400 / 3000: loss 2.302605
iteration 1500 / 3000: loss 2.302570
iteration 1600 / 3000: loss 2.302541
iteration 1700 / 3000: loss 2.302626
iteration 1800 / 3000: loss 2.302587
iteration 1900 / 3000: loss 2.302490
iteration 2000 / 3000: loss 2.302645
iteration 2100 / 3000: loss 2.302543
```

```
iteration 2200 / 3000: loss 2.302546
iteration 2300 / 3000: loss 2.302656
iteration 2400 / 3000: loss 2.302649
iteration 2500 / 3000: loss 2.302740
iteration 2600 / 3000: loss 2.302476
iteration 2700 / 3000: loss 2.302659
iteration 2800 / 3000: loss 2.302540
iteration 2900 / 3000: loss 2.302452
0.002 2e-05 175 3000 0.10044897959183674 0.078
```

In [ ]: *# Run your best neural net classifier on the test set. You should be able  
# to get more than 55% accuracy.*

```
test_acc = (best_net.predict(X_test_feats) == y_test).mean()
print(test_acc)
```

```
0.573
```