```
import tensorflow as tf
import tensorflow_datasets as tfds
from tensorflow.keras.applications import MobileNetV2
from tensorflow.keras.applications.mobilenet_v2 import
preprocess_input

!wget https://raw.githubusercontent.com/mrdbourke/tensorflow-deep-
learning/main/extras/helper_functions.py
from helper_functions import plot_loss_curves, compare_historys
```

```
--2025-02-15 08:02:21--
https://raw.githubusercontent.com/mrdbourke/tensorflow-deep-learning/
main/extras/helper_functions.py
Resolving raw.githubusercontent.com (raw.githubusercontent.com)...
185.199.108.133, 185.199.109.133, 185.199.110.133, ...
Connecting to raw.githubusercontent.com (raw.githubusercontent.com)|
185.199.108.133|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 10246 (10K) [text/plain]
Saving to: ‘helper_functions.py’

 helper_functions.py   0%[                    ]       0  --.-KB/s
helper_functions.py 100%[===================>]  10.01K  --.-KB/s    in
0.001s

2025-02-15 08:02:21 (18.8 MB/s) - ‘helper_functions.py’ saved
[10246/10246]
```

```
# Set hyperparameters
BATCH_SIZE = 64
IMG_SIZE = 96  # Upscale CIFAR-10 images (32x32) to a larger size for
MobileNetV2
AUTOTUNE = tf.data.AUTOTUNE

(ds_train, ds_test), ds_info = tfds.load(
    'cifar10',
    split=['train', 'test'],
    as_supervised=True,
    with_info=True
)
```

```
Downloading and preparing dataset 162.17 MiB (download: 162.17 MiB,
generated: 132.40 MiB, total: 294.58 MiB) to
/root/tensorflow_datasets/cifar10/3.0.2...
```


```
{"model_id":"c723b60c59164e14a1b70c70e0cd978d","version_major":2,"vers
ion_minor":0}

{"model_id":"60193aa443f5430097732ecc06054d99","version_major":2,"vers
ion_minor":0}
```

{"model_id":"6afffd2f7fc34ef09c95b34af2125378","version_major":2,"version_minor":0}

{"model_id":"71dbf97618a34eda8169fed0b90f69a7","version_major":2,"version_minor":0}

{"model_id":"73af50c170f04fa599363d75ab3e78f5","version_major":2,"version_minor":0}

{"model_id":"e23283024ec045f88cf16a938d8be86d","version_major":2,"version_minor":0}

{"model_id":"6671f0d90ce348898ac6c6959c835f48","version_major":2,"version_minor":0}

{"model_id":"01bde0b4ef3648d884343077a51bd6cc","version_major":2,"version_minor":0}

```
Dataset cifar10 downloaded and prepared to
/root/tensorflow_datasets/cifar10/3.0.2. Subsequent calls will reuse
this data.
```

```
ds_info.features
```

```
FeaturesDict({
    'id': Text(shape=(), dtype=string),
    'image': Image(shape=(32, 32, 3), dtype=uint8),
    'label': ClassLabel(shape=(), dtype=int64, num_classes=10),
})
```

```
class_names = ds_info.features['label'].names
class_names
```

```
['airplane',
 'automobile',
 'bird',
 'cat',
 'deer',
 'dog',
 'frog',
 'horse',
 'ship',
 'truck']
```

```
train_sample = ds_train.take(1) # takes one sample from train data
train_sample
```

```
<_TakeDataset element_spec=(TensorSpec(shape=(32, 32, 3),
dtype=tf.uint8, name=None), TensorSpec(shape=(), dtype=tf.int64,
name=None))>
```

```
for image, label in train_sample:
  print(f'''
  image_shape : {image.shape}
  image_datatype : {image.dtype}
  target_class : {label}
  class_name : {class_names[label.numpy()]}
  ''')
  )
```

```
  image_shape : (32, 32, 3)
  image_datatype : <dtype: 'uint8'>
  target_class : 7
  class_name : horse
```

```
import matplotlib.pyplot as plt
plt.figure(figsize=(1.5, 1.5))
plt.imshow(image)
plt.title(class_names[label.numpy()])
plt.axis(False)
```

```
(-0.5, 31.5, 31.5, -0.5)
```


```
len(ds_train), len(ds_test)
```

```
(50000, 10000)
```

```
#  data augmentation pipeline for training data
data_augmentation = tf.keras.Sequential([
    # Resize to desired IMG_SIZE
    tf.keras.layers.Resizing(IMG_SIZE, IMG_SIZE),
    tf.keras.layers.RandomFlip("horizontal"),
    tf.keras.layers.RandomRotation(0.1),
])

# Preprocessing function using MobileNetV2's preprocess_input
def preprocess(image, label):
    image = tf.cast(image, tf.float32)
    image = preprocess_input(image)
    return image, label
```

```
# Augmentation function (applied only on training set)
def augment(image, label):
    image = data_augmentation(image)
    return image, label

# Prepare the training dataset
ds_train = ds_train.map(augment, num_parallel_calls=AUTOTUNE)
ds_train = ds_train.map(preprocess, num_parallel_calls=AUTOTUNE)
ds_train = ds_train.shuffle(1000).batch(BATCH_SIZE).prefetch(AUTOTUNE)

# For the test dataset, only resize and preprocess (no augmentation)
def resize_and_preprocess(image, label):
    image = tf.cast(image, tf.float32)
    image = tf.image.resize(image, [IMG_SIZE, IMG_SIZE])
    image = preprocess_input(image)
    return image, label

ds_test = ds_test.map(resize_and_preprocess,
num_parallel_calls=AUTOTUNE)
ds_test = ds_test.batch(BATCH_SIZE).prefetch(AUTOTUNE)

# Build the model using MobileNetV2 as the base
base_model = MobileNetV2(
    include_top=False,
    weights='imagenet',
    input_shape=(IMG_SIZE, IMG_SIZE, 3)
)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/mobilenet_v2/
mobilenet_v2_weights_tf_dim_ordering_tf_kernels_1.0_96_no_top.h5
9406464/9406464 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step
```

```
base_model.trainable = False

inputs = tf.keras.Input(shape=(IMG_SIZE, IMG_SIZE, 3))
x = base_model(inputs, training=False)
x = tf.keras.layers.GlobalAveragePooling2D()(x)
x = tf.keras.layers.Dropout(0.2)(x)
outputs = tf.keras.layers.Dense(10, activation='softmax')(x)
model = tf.keras.Model(inputs, outputs)

model.compile(optimizer=tf.keras.optimizers.Adam(),
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

model.summary()
```

```
Model: "functional_1"
```

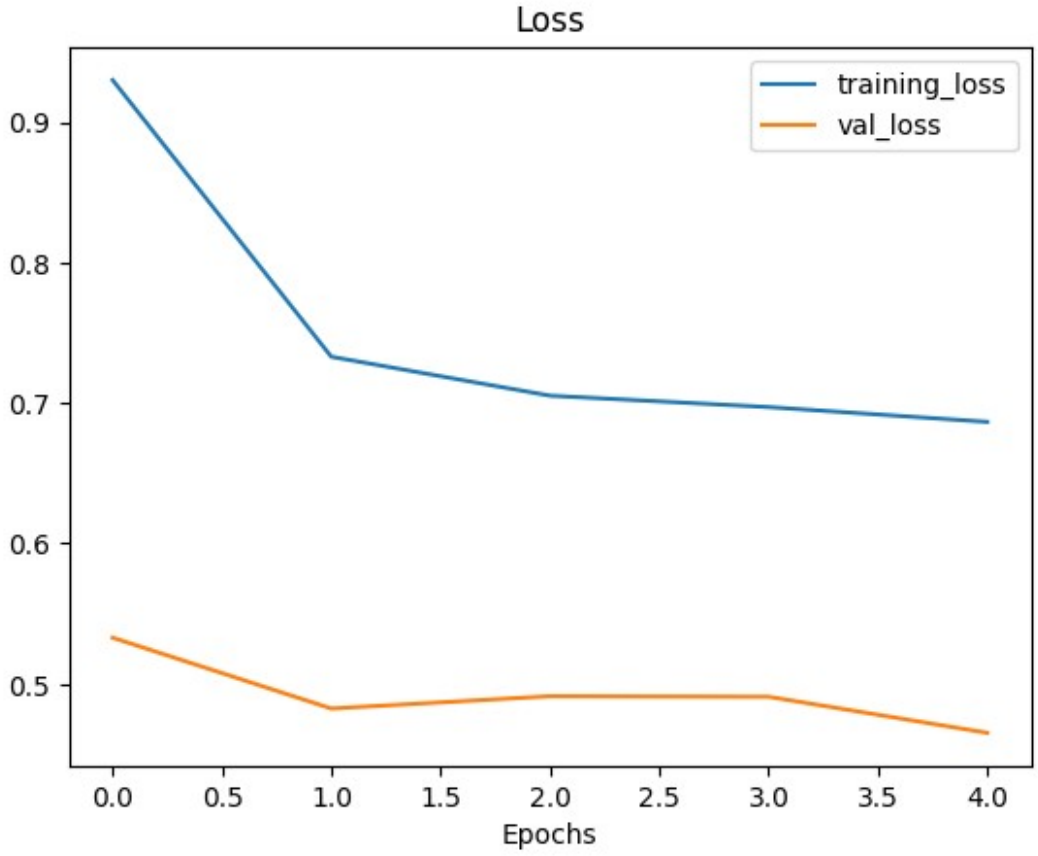
```
┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━┓
```

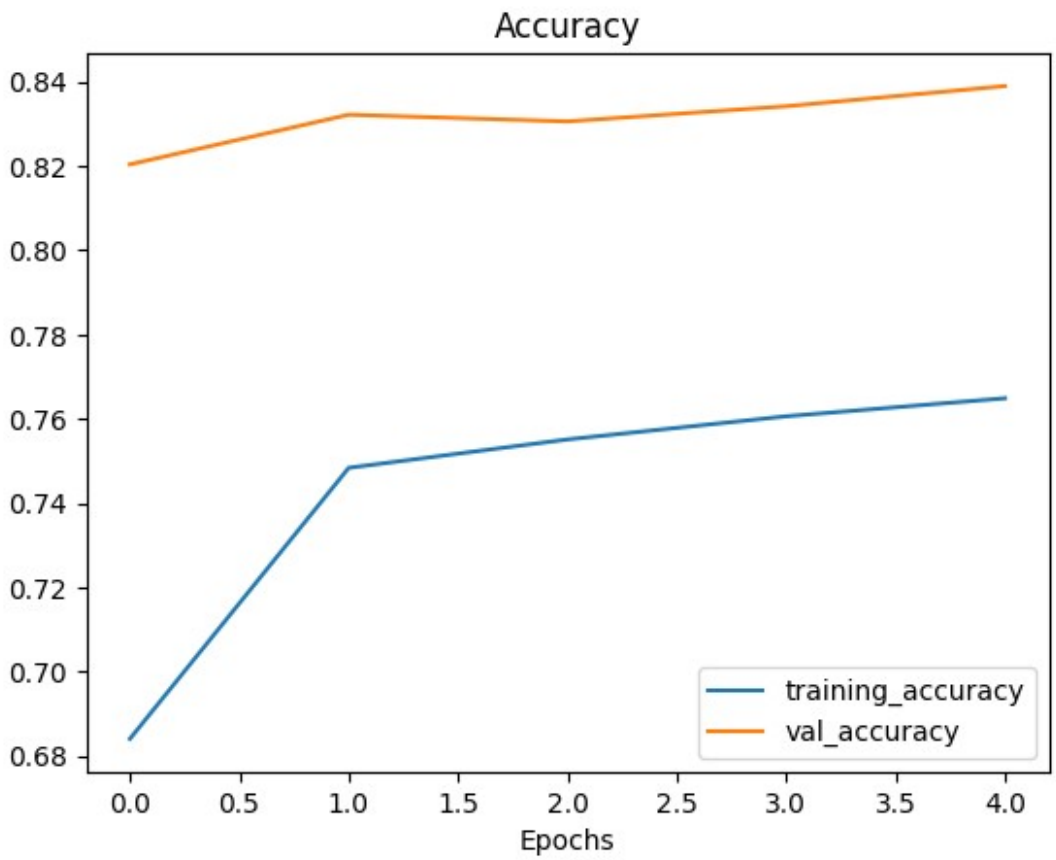
```
┃ Layer (type)                         ┃ Output Shape                ┃
Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇
━━━━━━━━━━━━━━━━━┩
│ input_layer_2 (InputLayer)           │ (None, 96, 96, 3)           │
0 │
├──────────────────────────────────────┼─────────────────────────────┼
─────────────────┤
│ mobilenetv2_1.00_96 (Functional)     │ (None, 3, 3, 1280)          │
2,257,984 │
├──────────────────────────────────────┼─────────────────────────────┼
─────────────────┤
│ global_average_pooling2d             │ (None, 1280)                │
0 │
│ (GlobalAveragePooling2D)             │                             │
│
├──────────────────────────────────────┼─────────────────────────────┼
─────────────────┤
│ dropout (Dropout)                    │ (None, 1280)                │
0 │
├──────────────────────────────────────┼─────────────────────────────┼
─────────────────┤
│ dense (Dense)                        │ (None, 10)                  │
12,810 │
└──────────────────────────────────────┴─────────────────────────────┴
─────────────────┘

 Total params: 2,270,794 (8.66 MB)

 Trainable params: 12,810 (50.04 KB)

 Non-trainable params: 2,257,984 (8.61 MB)
```

```
history = model.fit(
    ds_train,
    epochs=5,
    validation_data=ds_test
)
```

```
Epoch 1/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 129s 149ms/step - accuracy: 0.5983 -
loss: 1.1976 - val_accuracy: 0.8204 - val_loss: 0.5330
Epoch 2/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 105s 132ms/step - accuracy: 0.7455 -
loss: 0.7420 - val_accuracy: 0.8322 - val_loss: 0.4826
Epoch 3/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 106s 133ms/step - accuracy: 0.7520 -
loss: 0.7080 - val_accuracy: 0.8306 - val_loss: 0.4913
Epoch 4/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 104s 131ms/step - accuracy: 0.7584 -
```

```
loss: 0.7036 - val_accuracy: 0.8342 - val_loss: 0.4910
Epoch 5/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 147s 138ms/step - accuracy: 0.7661 -
loss: 0.6819 - val_accuracy: 0.8390 - val_loss: 0.4653

plot_loss_curves(history)
```

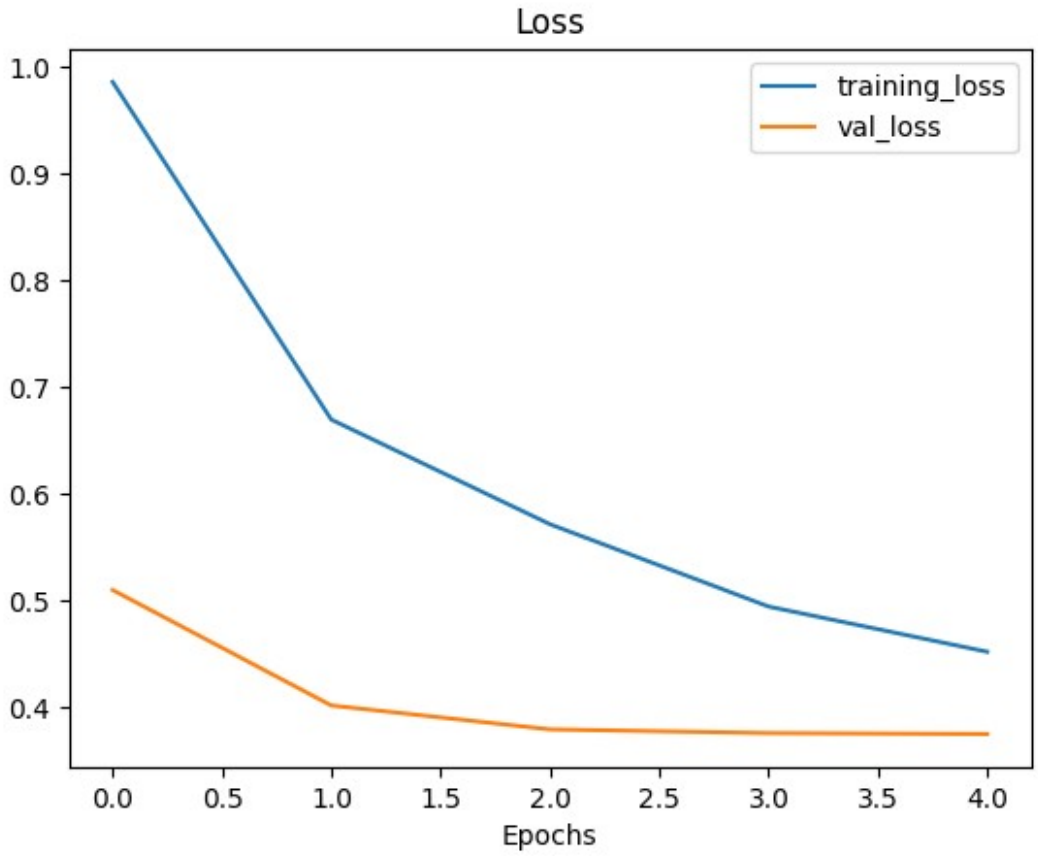


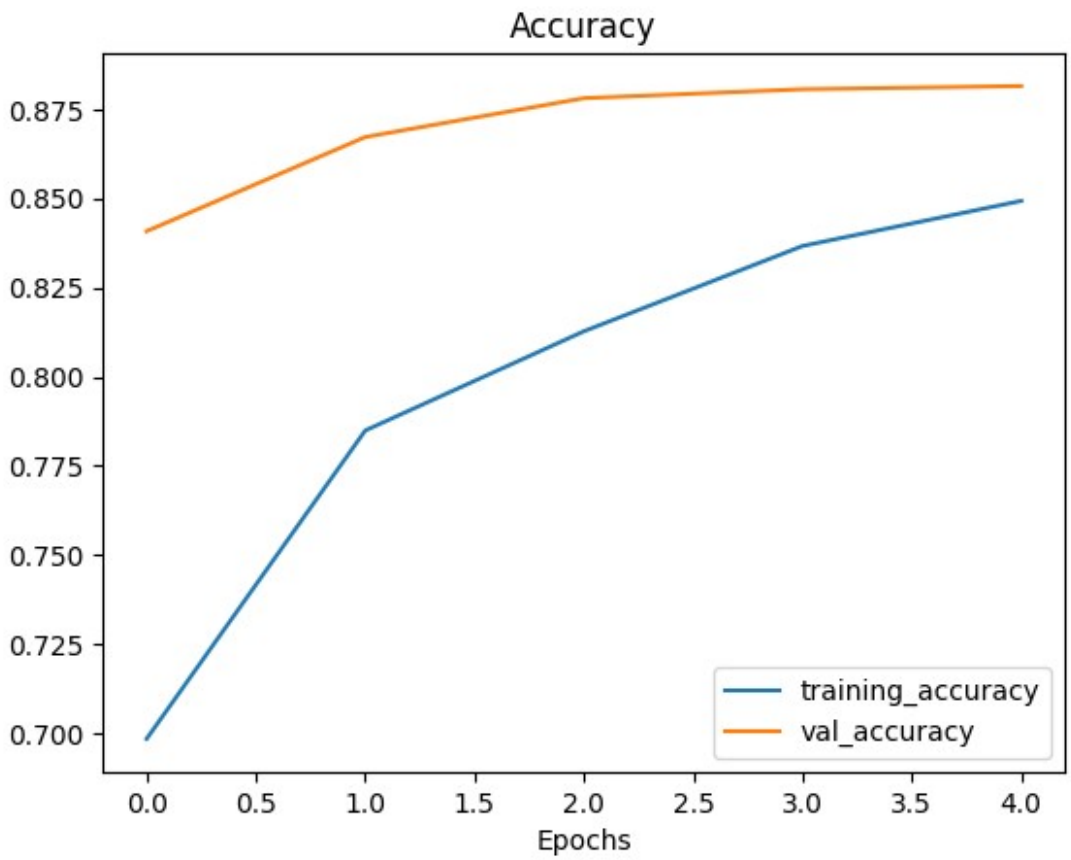



```
base_model.trainable = True
fine_tune_at = 25
for layer in base_model.layers[:fine_tune_at]:
    layer.trainable = False

model.compile(optimizer=tf.keras.optimizers.Adam(1e-5),
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(
    ds_train,
    epochs=5,
    validation_data=ds_test,
)
```

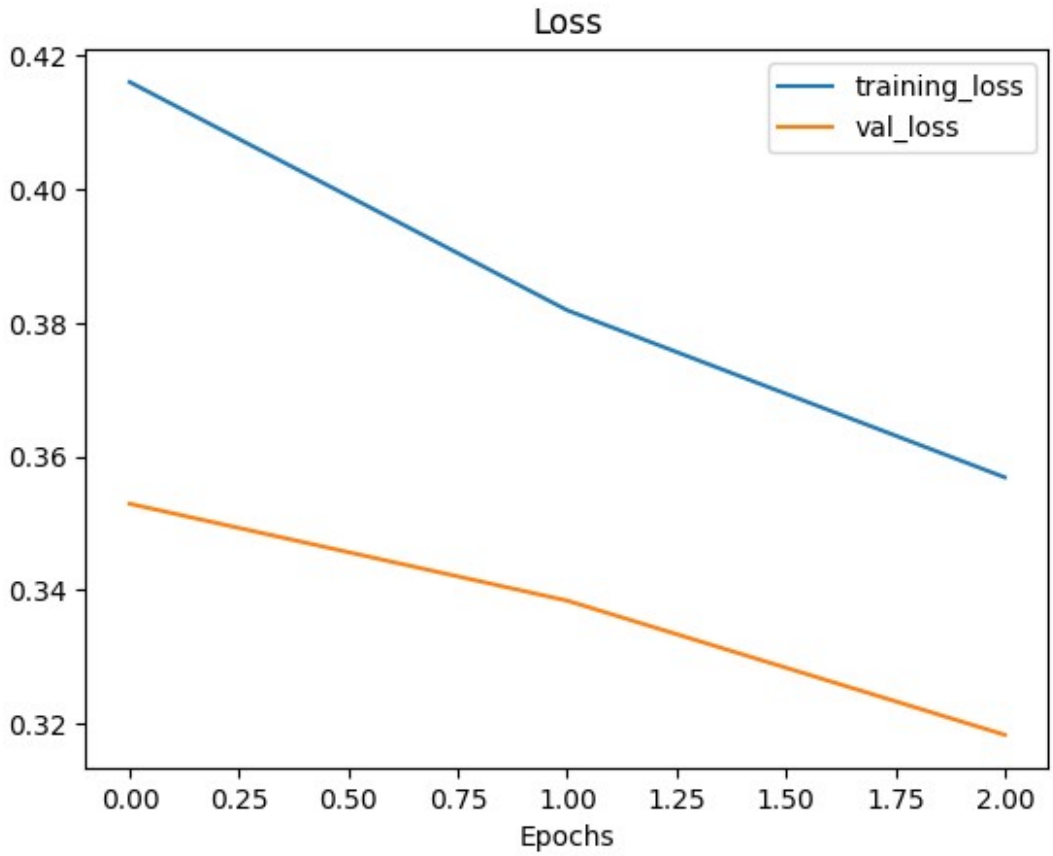
```
Epoch 1/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 206s 197ms/step - accuracy: 0.6337 -
loss: 1.2428 - val_accuracy: 0.8408 - val_loss: 0.5099
Epoch 2/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 129s 163ms/step - accuracy: 0.7762 -
loss: 0.7042 - val_accuracy: 0.8672 - val_loss: 0.4018
Epoch 3/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 139s 160ms/step - accuracy: 0.8082 -
```

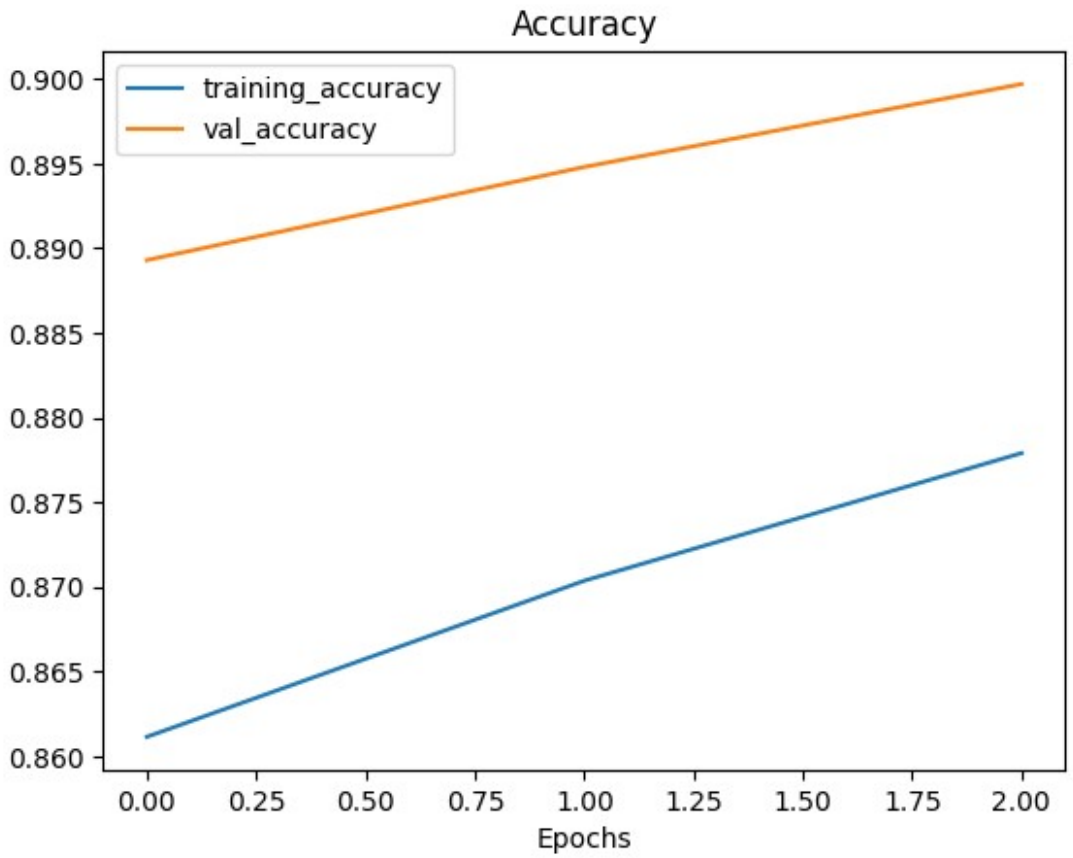
```
loss: 0.5913 - val_accuracy: 0.8781 - val_loss: 0.3795
Epoch 4/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 128s 162ms/step - accuracy: 0.8330 -
loss: 0.5092 - val_accuracy: 0.8806 - val_loss: 0.3760
Epoch 5/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 128s 161ms/step - accuracy: 0.8473 -
loss: 0.4601 - val_accuracy: 0.8815 - val_loss: 0.3751

plot_loss_curves(history)
```



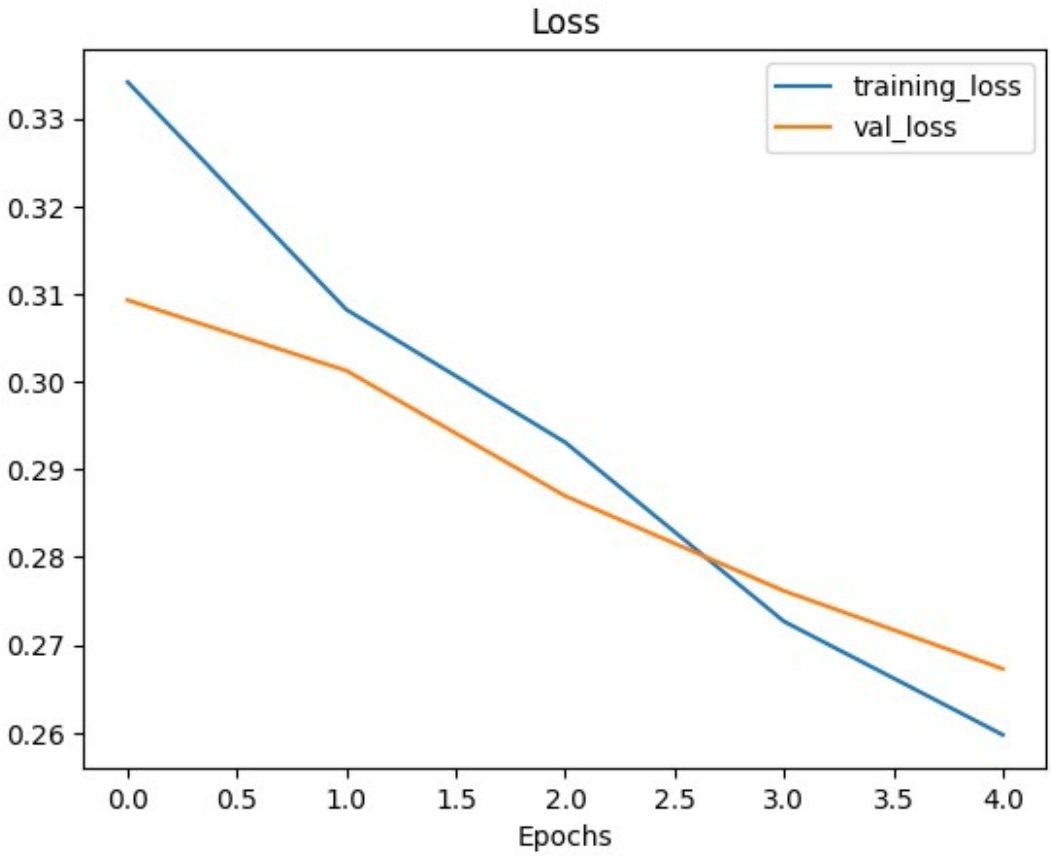


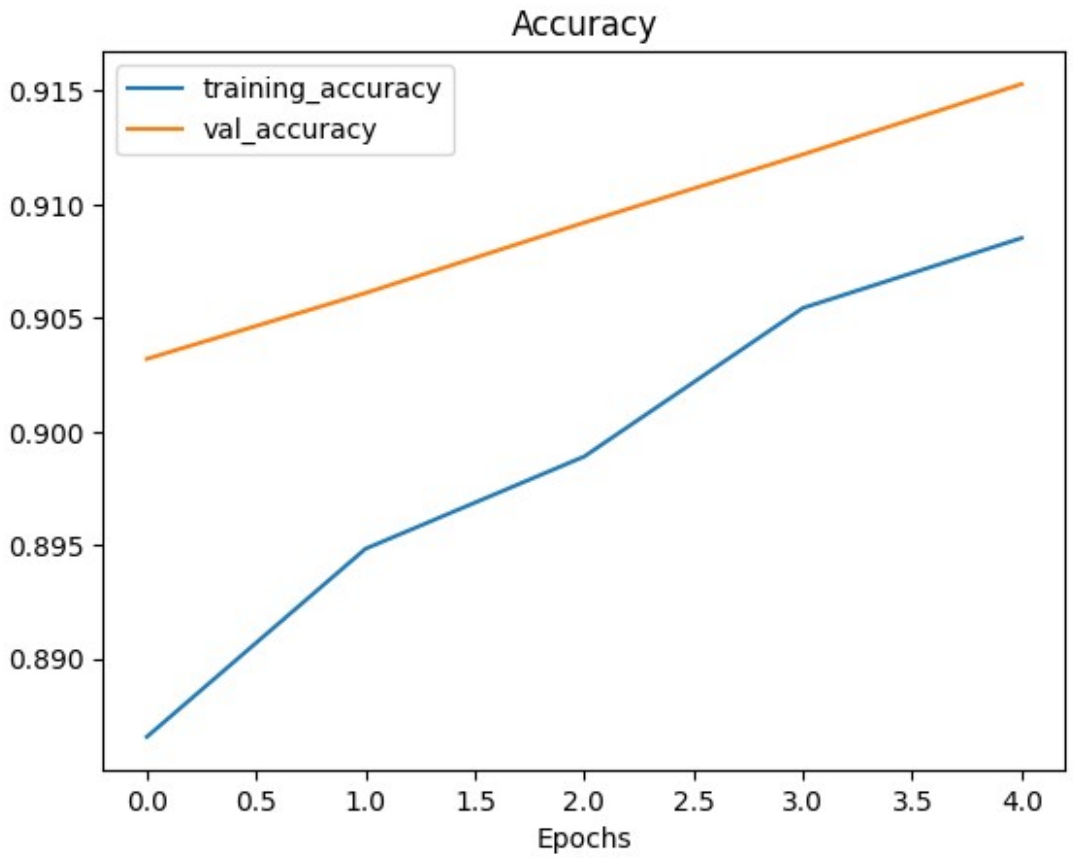

```
history = model.fit(
    ds_train,
    epochs=3,
    validation_data=ds_test,
)

Epoch 1/3
782/782 ━━━━━━━━━━━━━━━━━━━━ 130s 164ms/step - accuracy: 0.8579 -
loss: 0.4294 - val_accuracy: 0.8893 - val_loss: 0.3529
Epoch 2/3
782/782 ━━━━━━━━━━━━━━━━━━━━ 142s 165ms/step - accuracy: 0.8679 -
loss: 0.3882 - val_accuracy: 0.8948 - val_loss: 0.3384
Epoch 3/3
782/782 ━━━━━━━━━━━━━━━━━━━━ 131s 166ms/step - accuracy: 0.8745 -
loss: 0.3712 - val_accuracy: 0.8997 - val_loss: 0.3182

plot_loss_curves(history)
```


Loss
training_loss
val_loss
0.42
0.40
0.38
0.36
0.34
0.32
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Epochs




```
history = model.fit(
    ds_train,
    epochs=5,
    validation_data=ds_test,
)

Epoch 1/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 133s 166ms/step - accuracy: 0.8846 -
loss: 0.3405 - val_accuracy: 0.9032 - val_loss: 0.3093
Epoch 2/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 129s 163ms/step - accuracy: 0.8957 -
loss: 0.3091 - val_accuracy: 0.9061 - val_loss: 0.3013
Epoch 3/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 128s 162ms/step - accuracy: 0.8972 -
loss: 0.2990 - val_accuracy: 0.9092 - val_loss: 0.2870
Epoch 4/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 128s 161ms/step - accuracy: 0.9057 -
loss: 0.2721 - val_accuracy: 0.9122 - val_loss: 0.2762
Epoch 5/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 125s 158ms/step - accuracy: 0.9049 -
loss: 0.2712 - val_accuracy: 0.9153 - val_loss: 0.2673

plot_loss_curves(history)
```


Loss
training_loss
val_loss
0.33
0.32
0.31
0.30
0.29
0.28
0.27
0.26
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Epochs




```
model.save("fine_tuned_model.keras")
model.save("fine_tuned_model.h5", save_format='h5')
```

```
WARNING:absl:The `save_format` argument is deprecated in Keras 3. We recommend removing this argument as it can be inferred from the file path. Received: save_format=h5
WARNING:absl:You are saving your model as an HDF5 file via `model.save()` or `keras.saving.save_model(model)`. This file format is considered legacy. We recommend using instead the native Keras format, e.g. `model.save('my_model.keras')` or `keras.saving.save_model(model, 'my_model.keras')`.
```

```
loaded_model = tf.keras.models.load_model("fine_tuned_model.keras")
```

```
IMG_SIZE = 96  #matches the training size
BATCH_SIZE = 64
AUTOTUNE = tf.data.AUTOTUNE

# Load full CIFAR-10 dataset
ds_full, ds_info = tfds.load(
    'cifar10',
    split='train+test',
    as_supervised=True,
```

```
    with_info=True
)

def preprocess(image, label):
    image = tf.cast(image, tf.float32)
    image = tf.image.resize(image, [IMG_SIZE, IMG_SIZE])
    image = preprocess_input(image)
    return image, label

# Prepare dataset (apply preprocessing, batch, and prefetch)
ds_full = ds_full.map(preprocess, num_parallel_calls=AUTOTUNE)
ds_full = ds_full.batch(BATCH_SIZE).prefetch(AUTOTUNE)

loss, accuracy = model.evaluate(ds_full)
loss, accuracy
```

```
938/938 ━━━━━━━━━━━━━━━━━━━━ 27s 28ms/step - accuracy: 0.9364 - loss:
0.1922
```

```
(0.16968880593776703, 0.9430000185966492)
```