In [1]:
```
#Importing libraries
import warnings
warnings.filterwarnings("ignore")
```

In [37]:
```
import keras
from keras.datasets import cifar10

from keras.models import Sequential
import matplotlib.pyplot as plt

from pathlib import Path
from matplotlib import pyplot
import numpy as np
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import train_test_split
```

In [3]:
```
#Creating result directory
results_dir = Path('/Users/somashekarvayuvegula/Documents/Workspace/Big_Data/assignment0
results_dir.mkdir(parents=True, exist_ok=True)
```

Assignment 6.2a

Load dataset

In [4]:
```
(x_train, y_train),(x_test,y_test) = cifar10.load_data()
```

In [5]:
```
print('x_train shape:', x_train.shape)
print('y_train shape:', y_train.shape)

print(x_train.shape[0], 'train samples')
print(x_test.shape[0], 'test samples')
```

```
x_train shape: (50000, 32, 32, 3)
y_train shape: (50000, 1)
50000 train samples
10000 test samples
```

In [6]:
```
x_train = x_train.astype('float32')
x_train /= 255
x_test = x_test.astype('float32')
x_test /= 255
x_val_train = x_train[:10000]
x_train = x_train[10000:]
#Convert target data to single array of shape (50000,) and (10000,)
y_train = y_train.reshape(y_train.shape[0])
y_test = y_test.reshape(y_test.shape[0])
y_val_train = y_train[:10000]
y_train = y_train[10000:]
```

In [7]:
```
#Build model

from keras.layers import Conv2D, Activation, MaxPooling2D, Dropout, Dense, Flatten
model = Sequential()
model.add(Conv2D(32, (3, 3),
                 padding='same',
                 input_shape=x_train.shape[1:]))
model.add(MaxPooling2D((2, 2)))
model.add(Conv2D(64, (3, 3), activation='relu'))
```

```
model.add(MaxPooling2D((2, 2)))
model.add(Conv2D(128, (3, 3), activation='relu'))
model.add(MaxPooling2D((2, 2)))
model.add(Flatten())
model.add(Dense(512, activation='relu'))
model.add(Dense(10, activation='sigmoid'))

model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 32, 32, 32)        896

 max_pooling2d (MaxPooling2D  (None, 16, 16, 32)       0
 )

 conv2d_1 (Conv2D)           (None, 14, 14, 64)        18496

 max_pooling2d_1 (MaxPooling  (None, 7, 7, 64)         0
 2D)

 conv2d_2 (Conv2D)           (None, 5, 5, 128)         73856

 max_pooling2d_2 (MaxPooling  (None, 2, 2, 128)        0
 2D)

 flatten (Flatten)           (None, 512)               0

 dense (Dense)               (None, 512)               262656

 dense_1 (Dense)             (None, 10)                5130

=================================================================
Total params: 361,034
Trainable params: 361,034
Non-trainable params: 0
_________________________________________________________________
```

In [8]:
```
model.compile(loss='sparse_categorical_crossentropy',
              optimizer=keras.optimizers.RMSprop(learning_rate=0.0001, decay=1e-6),
              metrics=['acc'])
```

In [9]:
```
history = model.fit(x_train,
                    y_train,
                    batch_size=128,
                    epochs = 100,
                    validation_data=(x_val_train, y_val_train),
                    verbose=False)
```

In [10]:
```
# Evaluate the model
results = model.evaluate(x_test, y_test)
print(results)
```

```
313/313 [==============================] - 19s 61ms/step - loss: 1.1274 - acc: 0.6753
[1.1273853778839111, 0.6753000020980835]
```

In [11]:
```
history_dict = history.history

acc = history_dict['acc']
val_acc = history_dict['val_acc']
loss_values = history_dict['loss']
val_loss_values = history_dict['val_loss']
epochs = range(1,len(acc) + 1)
```

In [12]:
```
# Saving Model files to results folder
result_model_file = results_dir.joinpath('Assignment_6.2a_model.h5')
model.save(result_model_file)
print('Saved 6.2a trained model to results folder')
```

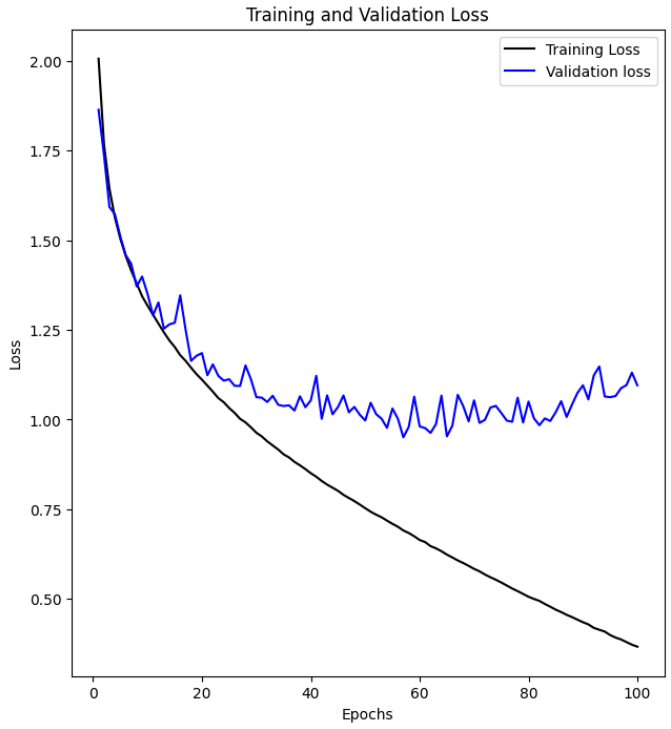
```
Saved 6.2a trained model to results folder
```

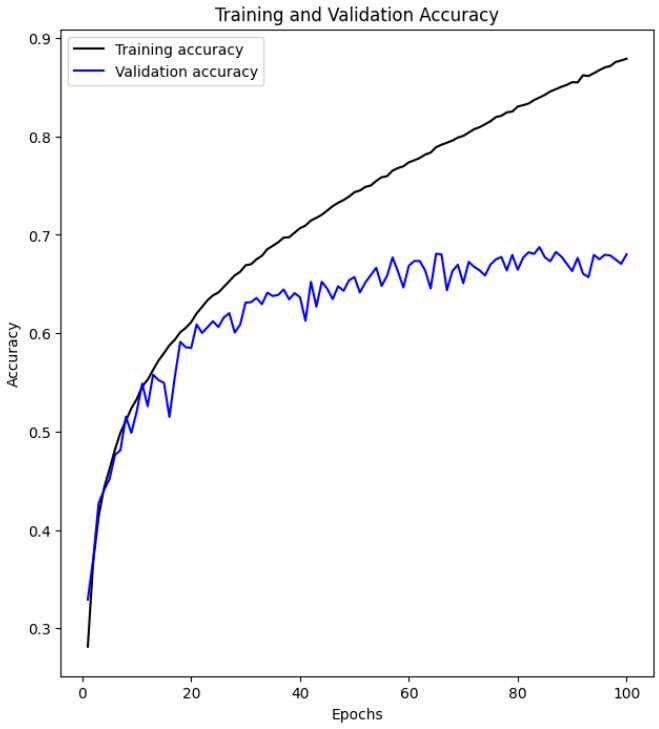
Plotting metrics

In [13]:
```
fig, [ax1, ax2] = plt.subplots(1,2, figsize=(16,8))

ax1.plot(epochs, loss_values,  'k', label = 'Training Loss')
ax1.plot(epochs, val_loss_values, 'b', label = 'Validation loss')
ax1.set_title('Training and Validation Loss')
ax1.set_xlabel("Epochs")
ax1.set_ylabel("Loss")
ax1.legend()

ax2.plot(epochs, acc,  'k', label = 'Training accuracy')
ax2.plot(epochs, val_acc, 'b', label = 'Validation accuracy')
ax2.set_title('Training and Validation Accuracy')
ax2.set_xlabel("Epochs")
ax2.set_ylabel("Accuracy")
ax2.legend()
img_file = results_dir.joinpath('Assignment_6.2a_Training_and_Validation_Loss_Accuracy.p
plt.savefig(img_file)
plt.show()
```





Assignment 6.2b

In [14]:
```
model = Sequential()
model.add(Conv2D(32, (3, 3), padding='same',
                 input_shape=x_train.shape[1:]))
model.add(Activation('relu'))
model.add(Conv2D(32, (3, 3)))
model.add(Activation('relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
```

```
model.add(Dropout(0.25))
model.add(Conv2D(64, (3, 3), padding='same'))
model.add(Activation('relu'))
model.add(Conv2D(64, (3, 3)))
model.add(Activation('relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))
model.add(Flatten())
model.add(Dense(512))
model.add(Activation('relu'))
model.add(Dropout(0.5))
model.add(Dense(10))
model.add(Activation('softmax'))
```

In [15]:
```
model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                 Output Shape              Param #
=================================================================
 conv2d_3 (Conv2D)            (None, 32, 32, 32)        896

 activation (Activation)      (None, 32, 32, 32)        0

 conv2d_4 (Conv2D)            (None, 30, 30, 32)        9248

 activation_1 (Activation)    (None, 30, 30, 32)        0

 max_pooling2d_3 (MaxPooling  (None, 15, 15, 32)        0
 2D)

 dropout (Dropout)            (None, 15, 15, 32)        0

 conv2d_5 (Conv2D)            (None, 15, 15, 64)        18496

 activation_2 (Activation)    (None, 15, 15, 64)        0

 conv2d_6 (Conv2D)            (None, 13, 13, 64)        36928

 activation_3 (Activation)    (None, 13, 13, 64)        0

 max_pooling2d_4 (MaxPooling  (None, 6, 6, 64)          0
 2D)

 dropout_1 (Dropout)          (None, 6, 6, 64)          0

 flatten_1 (Flatten)          (None, 2304)              0

 dense_2 (Dense)              (None, 512)               1180160

 activation_4 (Activation)    (None, 512)               0

 dropout_2 (Dropout)          (None, 512)               0

 dense_3 (Dense)              (None, 10)                5130

 activation_5 (Activation)    (None, 10)                0

=================================================================
Total params: 1,250,858
Trainable params: 1,250,858
Non-trainable params: 0
_________________________________________________________________
```

In [16]:
```
model.compile(loss='sparse_categorical_crossentropy',
```

```
              optimizer=keras.optimizers.RMSprop(learning_rate=0.0001, decay=1e-6),
              metrics=['acc'])
```

In [17]:
```
from keras.preprocessing.image import ImageDataGenerator
datagen = ImageDataGenerator(
    rotation_range=40,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True)

datagen.fit(x_train)

history = model.fit(datagen.flow(x_train,
                                 y_train,
                                 batch_size=128),
                    epochs=100,
                    validation_data=(x_val_train, y_val_train),
                    workers=4,
                    verbose=False)
```

In [18]:
```
results = model.evaluate(x_test, y_test)
print(results)
```

```
313/313 [==============================] - 4320s 14s/step - loss: 0.9236 - acc: 0.6788
[0.9235966801643372, 0.6787999868392944]
```

In [19]:
```
history_dict = history.history

acc = history_dict['acc']
val_acc = history_dict['val_acc']
loss_values = history_dict['loss']
val_loss_values = history_dict['val_loss']
epochs = range(1,len(acc) + 1)
```

In [20]:
```
# Saving Model files to results folder
result_model_file = results_dir.joinpath('Assignment_6.2b_model.h5')
model.save(result_model_file)
print('Saved 6.2b trained model to results folder')
```

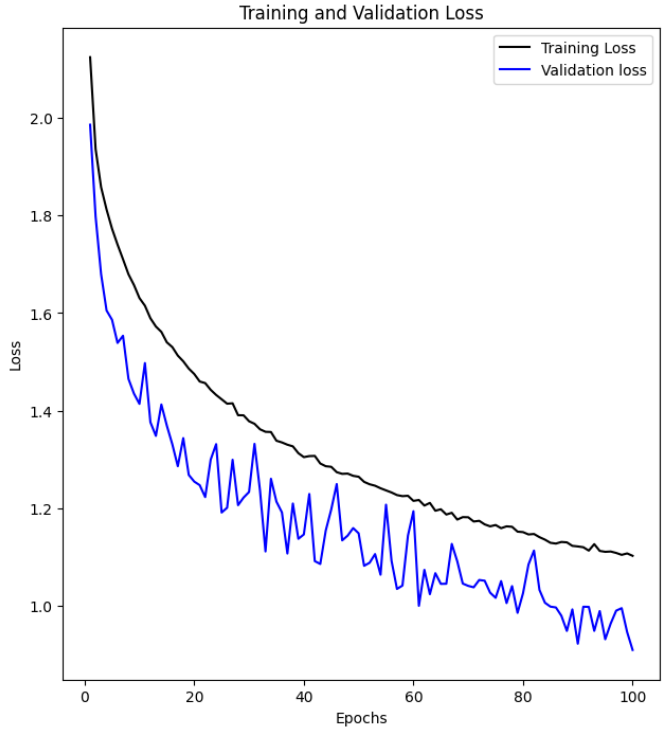
```
Saved 6.2b trained model to results folder
```

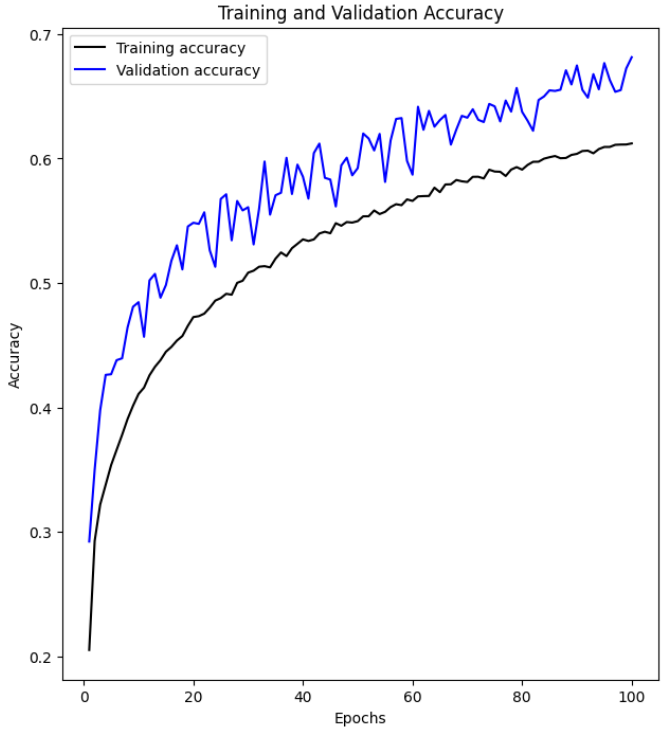
Plotting metrics

In [21]:
```
fig, [ax1, ax2] = plt.subplots(1,2, figsize=(16,8))

ax1.plot(epochs, loss_values,  'k', label = 'Training Loss')
ax1.plot(epochs, val_loss_values, 'b', label = 'Validation loss')
ax1.set_title('Training and Validation Loss')
ax1.set_xlabel("Epochs")
ax1.set_ylabel("Loss")
ax1.legend()

ax2.plot(epochs, acc,  'k', label = 'Training accuracy')
ax2.plot(epochs, val_acc, 'b', label = 'Validation accuracy')
ax2.set_title('Training and Validation Accuracy')
ax2.set_xlabel("Epochs")
ax2.set_ylabel("Accuracy")
ax2.legend()
img_file = results_dir.joinpath('Assignment_6.2b_Training_and_Validation_Loss_Accuracy.p
plt.savefig(img_file)
plt.show()
```


Training and Validation Loss
Training Loss
Validation loss
Loss
Epochs
2.0
1.8
1.6
1.4
1.2
1.0
0
20
40
60
80
100


Training and Validation Accuracy
Training accuracy
Validation accuracy
Accuracy
Epochs
0.7
0.6
0.5
0.4
0.3
0.2
0
20
40
60
80
100

In [ ]: