In [1]:
```python
# import to load dataset
import os
from torchvision import datasets, transforms
from torch.utils.data import random_split, DataLoader
import torch
import torch.nn as nn
import torch.nn.functional as F
import matplotlib.pyplot as plt
import numpy as np
import torch.optim as optim
from numba import cuda
use_cuda = torch.cuda.is_available()
import torchvision.transforms as T
import torchvision.datasets as D
import random
from torch.utils.data import Subset
```

In [2]:
```python
import os

large_dataset     = ['CNV', 'DME', 'DRUSEN', 'NORMAL']
large_dataset_dir = '/lambda/nfs/resnet-filesystem/OCT_by_class'
# only count these as “images”:
valid_exts = ('.png', '.jpg', '.jpeg')

def num_images(dataset_dir, folders):
    print(f"Number of images in each folder:")
    for folder in folders:
        path = os.path.join(dataset_dir, folder)
        if os.path.isdir(path):
            # only count files whose name ends with one of valid_exts
            num_files = sum(
                1 for fname in os.listdir(path)
                if fname.lower().endswith(valid_exts)
            )
            print(f"{folder}: {num_files}")
        else:
            print(f"Folder '{folder}' does not exist in the dataset directory.")

num_images(large_dataset_dir, large_dataset)
```

```
Number of images in each folder:
CNV: 3000
DME: 3000
DRUSEN: 3000
NORMAL: 3000
```

In [3]:
```python
from torchvision import transforms as T
from torchvision.datasets import ImageFolder
from torch.utils.data import random_split, DataLoader
```

In [4]:
```python
# import to load dataset
from torchvision.datasets import ImageFolder
from torch.utils.data import random_split, DataLoader
import torch

transform = T.ToTensor()
dataset = ImageFolder(root=large_dataset_dir, transform=transform)

# split the data: 70% training, 15% validation, 15% testing
total_len = len(dataset)
train_len = int(0.7 * total_len)
val_len = int(0.15 * total_len)
test_len = total_len - train_len - val_len
train_data, val_data, test_data = random_split(dataset, [train_len, val_len, test_len], generator=torch.Generator().manual_seed(42))

# define dataloader parameters
batch_size = 32

# prepare data loaders
train_loader = DataLoader(train_data, batch_size=batch_size, shuffle=True)
val_loader = DataLoader(val_data, batch_size=batch_size, shuffle=False)
test_loader = DataLoader(test_data, batch_size=batch_size, shuffle=False)

# check the number of training, validation, and test images alongside the percentage of training, validation, and testing (check)
print(f"Number of training images: {len(train_data)}  Percent: {100 * len(train_data)/total_len:.2f}")
print(f"Number of validation images: {len(val_data)}  Percent: {100 * len(val_data)/total_len:.2f}")
print(f"Number of test images: {len(test_data)}  Percent: {100 * len(test_data)/total_len:.2f}")
```

```
Number of training images: 8400  Percent: 70.00
Number of validation images: 1800  Percent: 15.00
Number of test images: 1800  Percent: 15.00
```

In [5]:
```python
import torch
import torch.nn as nn
import torch.optim as optim
from torchvision import models, transforms
from torch.utils.data import DataLoader
from torchvision.datasets import ImageFolder
```

In [6]:
```python
def get_accuracy(model, data_loader):
    correct = 0
    total = 0
    for imgs, labels in data_loader:

        #############################################
        #To Enable GPU Usage
        if use_cuda and torch.cuda.is_available():
          imgs = imgs.cuda()
          labels = labels.cuda()
        #############################################
```

```
        output = model(imgs)

        # select index with maximum prediction score
        pred = output.max(1, keepdim=True)[1]
        correct += pred.eq(labels.view_as(pred)).sum().item()
        total += imgs.shape[0]
    return correct / total
```

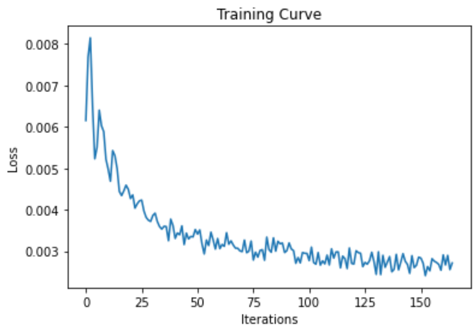
In [7]:
```
from tqdm import tqdm
import torch.nn as nn
import torch.optim as optim
import matplotlib.pyplot as plt

def train(model, train_data, val_data, batch_size=64, learning_rate = 0.001, num_epochs=20):
    from torch.utils.data import DataLoader

    train_loader = DataLoader(
        train_data,
        batch_size=batch_size,
        shuffle=True,
        num_workers=4,
        pin_memory=True,
        prefetch_factor=2
    )

    val_loader = DataLoader(
        val_data,
        batch_size=batch_size,
        shuffle=False,
        num_workers=4,
        pin_memory=True
    )

    criterion = nn.CrossEntropyLoss()
    optimizer = optim.Adam(model.parameters(), lr=learning_rate)

    iters, losses, train_acc, val_acc = [], [], [], []

    # training
    n = 0 # the number of iterations
    for epoch in range(num_epochs):
        for imgs, labels in tqdm(train_loader, desc="Training", leave=False):


            #############################################
            #To Enable GPU Usage
            if use_cuda and torch.cuda.is_available():
              imgs = imgs.cuda()
              labels = labels.cuda()
            #############################################


            out = model(imgs)             # forward pass
            loss = criterion(out, labels) # compute the total loss
            loss.backward()               # backward pass (compute parameter updates)
            optimizer.step()              # make the updates for each parameter
            optimizer.zero_grad()         # a clean up step for PyTorch

            # save the current training information
            iters.append(n)
            losses.append(float(loss)/batch_size)             # compute *average* loss
            train_acc.append(get_accuracy(model, train_loader)) # compute training accuracy
            val_acc.append(get_accuracy(model, val_loader))  # compute validation accuracy
            n += 1

        print(f"Epoch {epoch+1}: Train acc: {train_acc[-1]:.4f} | Validation acc: {val_acc[-1]:.4f}")
        torch.cuda.empty_cache()
        #model_path = get_model_name(model.name, batch_size, learning_rate, epoch)
        #torch.save(model.state_dict(), model_path)

    # plotting
    plt.title("Training Curve")
    plt.plot(iters, losses, label="Train")
    plt.xlabel("Iterations")
    plt.ylabel("Loss")
    plt.show()

    plt.title("Training Curve")
    plt.plot(iters, train_acc, label="Train")
    plt.plot(iters, val_acc, label="Validation")
    plt.xlabel("Iterations")
    plt.ylabel("Training Accuracy")
    plt.legend(loc='best')
    plt.show()

    print("Final Training Accuracy: {}".format(train_acc[-1]))
    print("Final Validation Accuracy: {}".format(val_acc[-1]))
```

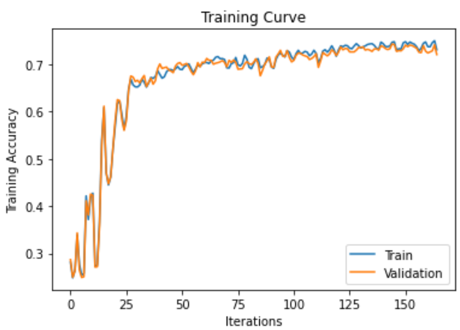
In [8]:
```
from torchvision.models import ResNet50_Weights
resnet50 = models.resnet50(weights=ResNet50_Weights.IMAGENET1K_V1)

# freeze weights
for param in resnet50.parameters():
    param.requires_grad = False

in_features = resnet50.fc.in_features
resnet50.fc = nn.Linear(in_features, 4)
```

In [10]:
```
use_cuda = True

if use_cuda and torch.cuda.is_available():
  resnet50 = resnet50.to('cuda:0')
```

```
    device = 'cuda:0'
    print('CUDA is available!  Training on GPU ...')
else:
    device = 'cpu'
    print('CUDA is not available.  Training on CPU ...')

train(resnet50, train_data, val_data, batch_size=256, learning_rate = 0.002, num_epochs=5)
```

```
CUDA is available!  Training on GPU ...

Epoch 1: Train acc: 0.6687 | Validation acc: 0.6700

Epoch 2: Train acc: 0.7154 | Validation acc: 0.7028

Epoch 3: Train acc: 0.7262 | Validation acc: 0.7150

Epoch 4: Train acc: 0.7374 | Validation acc: 0.7372

Epoch 5: Train acc: 0.7313 | Validation acc: 0.7211
```





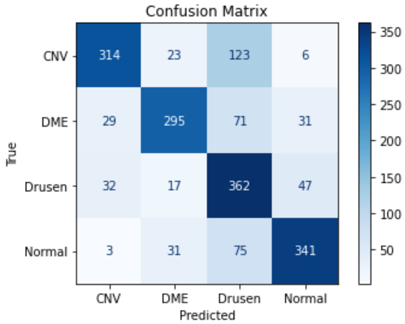

```
Final Training Accuracy: 0.7313095238095239
Final Validation Accuracy: 0.7211111111111111
```

In [11]:
```
# compute the test accuracy for restnet50
test_acc = get_accuracy(resnet50, test_loader)
print(f"Test accuracy: {test_acc:.4f}")
```

```
Test accuracy: 0.7200
```

In [12]:
```
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay

# confusion matrix
def plot_confusion_matrix(model, data_loader, class_names):
    # set model into evaluation mode
    model.eval()
    all_preds = []
    all_labels = []

    with torch.no_grad():
        for imgs, labels in data_loader:
            if use_cuda and torch.cuda.is_available():
                imgs = imgs.cuda()
                labels = labels.cuda()

            output = model(imgs)
            preds = output.argmax(dim=1)

            all_preds.extend(preds.cpu().numpy())
            all_labels.extend(labels.cpu().numpy())

    # compute the confusion matrix
    cm = confusion_matrix(all_labels, all_preds)

    # plot the confusion matrix
    disp = ConfusionMatrixDisplay(confusion_matrix=cm, display_labels=class_names)
    disp.plot(cmap='Blues', values_format='d')
    plt.title("Confusion Matrix")
    plt.xlabel('Predicted')
    plt.ylabel('True')
    plt.title('Confusion Matrix')
    plt.show()

    return cm
```

In [13]:
```
class_names = ['CNV', 'DME', 'Drusen', 'Normal']
plot_confusion_matrix(resnet50, test_loader, class_names)
```



Out[13]:
```
array([[314,  23, 123,   6],
       [ 29, 295,  71,  31],
       [ 32,  17, 362,  47],
       [  3,  31,  75, 341]])
```

In [14]:
```python
from sklearn.metrics import roc_curve, auc
from sklearn.preprocessing import label_binarize

# plot roc curve
def plot_roc_curve(model, data_loader, class_names):
    model.eval()
    all_labels = []
    all_probs = []

    with torch.no_grad():
        for imgs, labels in data_loader:
            if use_cuda and torch.cuda.is_available():
                imgs = imgs.cuda()
                labels = labels.cuda()

            output = model(imgs)
            probs = torch.softmax(output, dim=1)

            all_probs.extend(probs.cpu().numpy())
            all_labels.extend(labels.cpu().numpy())

    all_probs = np.array(all_probs)
    all_labels = np.array(all_labels)

    # binarize the labels for multi-class ROC
    y_true = label_binarize(all_labels, classes=np.arange(len(class_names)))
    n_classes = y_true.shape[1]

    # compute ROC and AUC for each class
    fpr = dict()
    tpr = dict()
    roc_auc = dict()

    for i in range(n_classes):
        fpr[i], tpr[i], _ = roc_curve(y_true[:, i], all_probs[:, i])
        roc_auc[i] = auc(fpr[i], tpr[i])

    # plot the ROC curve
    plt.figure()
    for i in range(n_classes):
        plt.plot(fpr[i], tpr[i], label=f"{class_names[i]} (AUC = {roc_auc[i]:.2f})")

    plt.plot([0, 1], [0, 1], 'k--')  # random classfier
    plt.xlabel('False Positive Rate')
    plt.ylabel('True Positive Rate')
    plt.title('Receiver Operating Characteristic (ROC) Curve')
    plt.legend(loc='lower right')
    plt.grid(True)
    plt.show()

    return roc_auc
```

In [15]:
```python
roc_auc = plot_roc_curve(resnet50, test_loader, class_names)
```