Collaboration and Competition

You are welcome to use this coding environment to train your agent for the project. Follow the instructions below to get started!

1. Start the Environment

Run the next code cell to install a few packages. This line will take a few minutes to run!

```
In [1]: !pip -q install ./python
```

```
tensorflow 1.7.1 has requirement numpy>=1.13.3, but you'll have numpy 1.12.1 which is incompatible.
ipython 6.5.0 has requirement prompt-toolkit<2.0.0,>=1.0.15, but you'll have prompt-toolkit 3.0.3 which is in
compatible.
```

The environment is already saved in the Workspace and can be accessed at the file path provided below.

```
In [2]: import copy
        import matplotlib.pyplot as plt
        import numpy as np
        import random
        import torch
        import torch.nn as nn
        import torch.nn.functional as F
        import torch.optim as optim
        import time
        from multiagents import MultiAgents
        from collections import namedtuple, deque
        from unityagents import UnityEnvironment
```

```
In [3]:  env = UnityEnvironment(file_name="/data/Tennis_Linux_NoVis/Tennis",no_graphics=True)
```

```
INFO:unityagents:
'Academy' started successfully!
Unity Academy name: Academy
        Number of Brains: 1
        Number of External Brains : 1
        Lesson number : 0
        Reset Parameters :

Unity brain name: TennisBrain
        Number of Visual Observations (per agent): 0
        Vector Observation space type: continuous
        Vector Observation space size (per agent): 8
        Number of stacked Vector Observation: 3
        Vector Action space type: continuous
        Vector Action space size (per agent): 2
        Vector Action descriptions: ,
```

Environments contain **brains** which are responsible for deciding the actions of their associated agents. Here we check for the first brain available, and set it as the default brain we will be controlling from Python.

```
In [4]:  # get the default brain
         brain_name = env.brain_names[0]
         brain = env.brains[brain_name]
```

```
In [6]:  # reset the environment
         env_info = env.reset(train_mode=True)[brain_name]

         # number of agents
         num_agents = len(env_info.agents)
         print('Number of agents:', num_agents)

         # size of each action
         action_size = brain.vector_action_space_size
         print('Size of each action:', action_size)

         # examine the state space
         states = env_info.vector_observations
         state_size = states.shape[1]
         print('There are {} agents. Each observes a state with length: {}'.format(states.shape[0], state_size))
         print('The state for the first agent looks like:', states[0])
```

```
Number of agents: 2
Size of each action: 2
There are 2 agents. Each observes a state with length: 24
The state for the first agent looks like: [ 0.          0.          0.          0.          0.          0.
 0.
   0.          0.          0.          0.          0.          0.          0.
   0.          0.         -6.65278625 -1.5         -0.          0.
   6.83172083  6.         -0.          0.         ]
```

```
In [5]:  max_num_timesteps = 1500
         n_episodes=3000
         random_seed=0
```

```
In [7]:  agent = MultiAgents(num_agents=2, state_size=state_size, action_size=action_size, random_seed=random_seed)
```

In [8]:
```python
def train():
    init_time = time.time()
    scores_deque = deque(maxlen=100)
    scores = []
    max_score = -np.Inf
    t0 = time.time()
    for i_episode in range(1, n_episodes+1):
        env_info = env.reset(train_mode=True)[brain_name]
        states = env_info.vector_observations
        agent.reset()
        agent_scores = np.zeros(num_agents)
        for t_step in range(max_num_timesteps):
            actions = agent.act(states)
            next_env_info = env.step(actions)[brain_name]
            next_states, rewards, dones = next_env_info.vector_observations, next_env_info.rewards, next_env_info.local_done
            agent.step(states, actions, rewards, next_states, dones)
            agent_scores = agent_scores + rewards
            states = next_states
            if np.any(dones):
                break

        scores_deque.append(np.max(agent_scores))
        scores.append(np.max(agent_scores))
        score_average = np.mean(scores_deque)
        t1 = (time.time()-t0)/60.

        print(f'Episode: {i_episode}\tTime(Min): {round(t1,2)}\tMax: {round(np.max(scores),2)}\tMin: {round(np.min(scores),2)}\tAvg queue: {round(np.mean(scores_deque),2)}')

        if len(scores_deque) == 100 and score_average >=0.5:
            print('Completed!')
            env.close()
            agent.save_maddpg()
            break
    return scores
```

In [9]:
```
%%time
results = train()
```

```
Episode: 1     Time(Min): 0.0  Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 2     Time(Min): 0.03 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 3     Time(Min): 0.03 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 4     Time(Min): 0.03 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 5     Time(Min): 0.03 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 6     Time(Min): 0.03 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 7     Time(Min): 0.03 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 8     Time(Min): 0.03 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 9     Time(Min): 0.03 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 10    Time(Min): 0.04 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 11    Time(Min): 0.04 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 12    Time(Min): 0.04 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 13    Time(Min): 0.04 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 14    Time(Min): 0.04 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 15    Time(Min): 0.04 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 16    Time(Min): 0.04 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 17    Time(Min): 0.04 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 18    Time(Min): 0.04 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 19    Time(Min): 0.05 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 20    Time(Min): 0.06 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 21    Time(Min): 0.07 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 22    Time(Min): 0.08 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 23    Time(Min): 0.09 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 24    Time(Min): 0.1  Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 25    Time(Min): 0.12 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 26    Time(Min): 0.13 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 27    Time(Min): 0.14 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 28    Time(Min): 0.15 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 29    Time(Min): 0.16 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 30    Time(Min): 0.17 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 31    Time(Min): 0.18 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 32    Time(Min): 0.19 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 33    Time(Min): 0.2  Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 34    Time(Min): 0.21 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 35    Time(Min): 0.22 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 36    Time(Min): 0.23 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 37    Time(Min): 0.24 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 38    Time(Min): 0.25 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 39    Time(Min): 0.26 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 40    Time(Min): 0.27 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 41    Time(Min): 0.28 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 42    Time(Min): 0.29 Max: 0.0        Min: 0.0        Avg queue: 0.0
Episode: 43    Time(Min): 0.3  Max: 0.0        Min: 0.0        Avg queue: 0.0
```

```
         Episode: 44      Time(Min): 0.31 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 45      Time(Min): 0.32 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 46      Time(Min): 0.34 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 47      Time(Min): 0.35 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 48      Time(Min): 0.36 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 49      Time(Min): 0.37 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 50      Time(Min): 0.38 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 51      Time(Min): 0.39 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 52      Time(Min): 0.4  Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 53      Time(Min): 0.41 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 54      Time(Min): 0.42 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 55      Time(Min): 0.43 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 56      Time(Min): 0.44 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 57      Time(Min): 0.45 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 58      Time(Min): 0.46 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 59      Time(Min): 0.47 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 60      Time(Min): 0.48 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 61      Time(Min): 0.49 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 62      Time(Min): 0.51 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 63      Time(Min): 0.52 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 64      Time(Min): 0.53 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 65      Time(Min): 0.54 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 66      Time(Min): 0.56 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 67      Time(Min): 0.57 Max: 0.0          Min: 0.0          Avg queue: 0.0
         Episode: 68      Time(Min): 0.58 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 69      Time(Min): 0.6  Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 70      Time(Min): 0.61 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 71      Time(Min): 0.62 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 72      Time(Min): 0.63 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 73      Time(Min): 0.64 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 74      Time(Min): 0.65 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 75      Time(Min): 0.66 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 76      Time(Min): 0.67 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 77      Time(Min): 0.68 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 78      Time(Min): 0.7  Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 79      Time(Min): 0.72 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 80      Time(Min): 0.73 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 81      Time(Min): 0.74 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 82      Time(Min): 0.75 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 83      Time(Min): 0.76 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 84      Time(Min): 0.77 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 85      Time(Min): 0.78 Max: 0.1          Min: 0.0          Avg queue: 0.0
         Episode: 86      Time(Min): 0.79 Max: 0.1          Min: 0.0          Avg queue: 0.0
```

```
          Episode: 87     Time(Min): 0.8  Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 88     Time(Min): 0.81 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 89     Time(Min): 0.82 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 90     Time(Min): 0.83 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 91     Time(Min): 0.85 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 92     Time(Min): 0.86 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 93     Time(Min): 0.87 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 94     Time(Min): 0.88 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 95     Time(Min): 0.89 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 96     Time(Min): 0.9  Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 97     Time(Min): 0.91 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 98     Time(Min): 0.92 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 99     Time(Min): 0.93 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 100    Time(Min): 0.94 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 101    Time(Min): 0.95 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 102    Time(Min): 0.96 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 103    Time(Min): 0.97 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 104    Time(Min): 0.98 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 105    Time(Min): 0.99 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 106    Time(Min): 1.0  Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 107    Time(Min): 1.01 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 108    Time(Min): 1.02 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 109    Time(Min): 1.04 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 110    Time(Min): 1.05 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 111    Time(Min): 1.07 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 112    Time(Min): 1.08 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 113    Time(Min): 1.09 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 114    Time(Min): 1.1  Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 115    Time(Min): 1.11 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 116    Time(Min): 1.12 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 117    Time(Min): 1.13 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 118    Time(Min): 1.14 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 119    Time(Min): 1.17 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 120    Time(Min): 1.18 Max: 0.1        Min: 0.0      Avg queue: 0.0
          Episode: 121    Time(Min): 1.19 Max: 0.1        Min: 0.0      Avg queue: 0.01
          Episode: 122    Time(Min): 1.2  Max: 0.1        Min: 0.0      Avg queue: 0.01
          Episode: 123    Time(Min): 1.23 Max: 0.1        Min: 0.0      Avg queue: 0.01
          Episode: 124    Time(Min): 1.25 Max: 0.1        Min: 0.0      Avg queue: 0.01
          Episode: 125    Time(Min): 1.26 Max: 0.1        Min: 0.0      Avg queue: 0.01
          Episode: 126    Time(Min): 1.27 Max: 0.1        Min: 0.0      Avg queue: 0.01
          Episode: 127    Time(Min): 1.29 Max: 0.1        Min: 0.0      Avg queue: 0.01
          Episode: 128    Time(Min): 1.3  Max: 0.1        Min: 0.0      Avg queue: 0.01
          Episode: 129    Time(Min): 1.31 Max: 0.1        Min: 0.0      Avg queue: 0.01
```

```
        Episode: 130    Time(Min): 1.34 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 131    Time(Min): 1.35 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 132    Time(Min): 1.37 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 133    Time(Min): 1.38 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 134    Time(Min): 1.39 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 135    Time(Min): 1.4  Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 136    Time(Min): 1.41 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 137    Time(Min): 1.42 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 138    Time(Min): 1.43 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 139    Time(Min): 1.44 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 140    Time(Min): 1.47 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 141    Time(Min): 1.49 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 142    Time(Min): 1.5  Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 143    Time(Min): 1.52 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 144    Time(Min): 1.53 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 145    Time(Min): 1.54 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 146    Time(Min): 1.55 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 147    Time(Min): 1.58 Max: 0.1      Min: 0.0       Avg queue: 0.01
        Episode: 148    Time(Min): 1.6  Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 149    Time(Min): 1.62 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 150    Time(Min): 1.64 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 151    Time(Min): 1.66 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 152    Time(Min): 1.67 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 153    Time(Min): 1.69 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 154    Time(Min): 1.7  Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 155    Time(Min): 1.71 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 156    Time(Min): 1.73 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 157    Time(Min): 1.74 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 158    Time(Min): 1.75 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 159    Time(Min): 1.76 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 160    Time(Min): 1.78 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 161    Time(Min): 1.79 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 162    Time(Min): 1.8  Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 163    Time(Min): 1.81 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 164    Time(Min): 1.82 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 165    Time(Min): 1.85 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 166    Time(Min): 1.87 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 167    Time(Min): 1.88 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 168    Time(Min): 1.89 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 169    Time(Min): 1.9  Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 170    Time(Min): 1.91 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 171    Time(Min): 1.93 Max: 0.1      Min: 0.0       Avg queue: 0.02
        Episode: 172    Time(Min): 1.94 Max: 0.1      Min: 0.0       Avg queue: 0.02
```

```
        Episode: 173    Time(Min): 1.96 Max: 0.1      Min: 0.0      Avg queue: 0.02
        Episode: 174    Time(Min): 1.98 Max: 0.1      Min: 0.0      Avg queue: 0.02
        Episode: 175    Time(Min): 2.0  Max: 0.1      Min: 0.0      Avg queue: 0.02
        Episode: 176    Time(Min): 2.02 Max: 0.1      Min: 0.0      Avg queue: 0.02
        Episode: 177    Time(Min): 2.03 Max: 0.1      Min: 0.0      Avg queue: 0.02
        Episode: 178    Time(Min): 2.05 Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 179    Time(Min): 2.07 Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 180    Time(Min): 2.08 Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 181    Time(Min): 2.12 Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 182    Time(Min): 2.15 Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 183    Time(Min): 2.17 Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 184    Time(Min): 2.2  Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 185    Time(Min): 2.22 Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 186    Time(Min): 2.24 Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 187    Time(Min): 2.27 Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 188    Time(Min): 2.29 Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 189    Time(Min): 2.31 Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 190    Time(Min): 2.33 Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 191    Time(Min): 2.36 Max: 0.1      Min: 0.0      Avg queue: 0.03
        Episode: 192    Time(Min): 2.38 Max: 0.1      Min: 0.0      Avg queue: 0.04
        Episode: 193    Time(Min): 2.4  Max: 0.1      Min: 0.0      Avg queue: 0.04
        Episode: 194    Time(Min): 2.45 Max: 0.19     Min: 0.0      Avg queue: 0.04
        Episode: 195    Time(Min): 2.48 Max: 0.19     Min: 0.0      Avg queue: 0.04
        Episode: 196    Time(Min): 2.51 Max: 0.19     Min: 0.0      Avg queue: 0.04
        Episode: 197    Time(Min): 2.52 Max: 0.19     Min: 0.0      Avg queue: 0.04
        Episode: 198    Time(Min): 2.54 Max: 0.19     Min: 0.0      Avg queue: 0.04
        Episode: 199    Time(Min): 2.59 Max: 0.2      Min: 0.0      Avg queue: 0.04
        Episode: 200    Time(Min): 2.62 Max: 0.2      Min: 0.0      Avg queue: 0.04
        Episode: 201    Time(Min): 2.64 Max: 0.2      Min: 0.0      Avg queue: 0.05
        Episode: 202    Time(Min): 2.72 Max: 0.29     Min: 0.0      Avg queue: 0.05
        Episode: 203    Time(Min): 2.77 Max: 0.29     Min: 0.0      Avg queue: 0.05
        Episode: 204    Time(Min): 2.78 Max: 0.29     Min: 0.0      Avg queue: 0.05
        Episode: 205    Time(Min): 2.9  Max: 0.39     Min: 0.0      Avg queue: 0.05
        Episode: 206    Time(Min): 2.92 Max: 0.39     Min: 0.0      Avg queue: 0.06
        Episode: 207    Time(Min): 2.97 Max: 0.39     Min: 0.0      Avg queue: 0.06
        Episode: 208    Time(Min): 2.99 Max: 0.39     Min: 0.0      Avg queue: 0.06
        Episode: 209    Time(Min): 3.02 Max: 0.39     Min: 0.0      Avg queue: 0.06
        Episode: 210    Time(Min): 3.03 Max: 0.39     Min: 0.0      Avg queue: 0.06
        Episode: 211    Time(Min): 3.04 Max: 0.39     Min: 0.0      Avg queue: 0.06
        Episode: 212    Time(Min): 3.06 Max: 0.39     Min: 0.0      Avg queue: 0.06
        Episode: 213    Time(Min): 3.07 Max: 0.39     Min: 0.0      Avg queue: 0.06
        Episode: 214    Time(Min): 3.08 Max: 0.39     Min: 0.0      Avg queue: 0.06
        Episode: 215    Time(Min): 3.13 Max: 0.39     Min: 0.0      Avg queue: 0.06
```

```
Episode: 216    Time(Min): 3.14 Max: 0.39      Min: 0.0      Avg queue: 0.06
Episode: 217    Time(Min): 3.19 Max: 0.39      Min: 0.0      Avg queue: 0.06
Episode: 218    Time(Min): 3.23 Max: 0.39      Min: 0.0      Avg queue: 0.06
Episode: 219    Time(Min): 3.28 Max: 0.39      Min: 0.0      Avg queue: 0.06
Episode: 220    Time(Min): 3.35 Max: 0.39      Min: 0.0      Avg queue: 0.07
Episode: 221    Time(Min): 3.55 Max: 0.6       Min: 0.0      Avg queue: 0.07
Episode: 222    Time(Min): 3.57 Max: 0.6       Min: 0.0      Avg queue: 0.07
Episode: 223    Time(Min): 3.59 Max: 0.6       Min: 0.0      Avg queue: 0.07
Episode: 224    Time(Min): 3.62 Max: 0.6       Min: 0.0      Avg queue: 0.07
Episode: 225    Time(Min): 3.64 Max: 0.6       Min: 0.0      Avg queue: 0.07
Episode: 226    Time(Min): 3.66 Max: 0.6       Min: 0.0      Avg queue: 0.07
Episode: 227    Time(Min): 3.74 Max: 0.6       Min: 0.0      Avg queue: 0.08
Episode: 228    Time(Min): 3.77 Max: 0.6       Min: 0.0      Avg queue: 0.08
Episode: 229    Time(Min): 3.79 Max: 0.6       Min: 0.0      Avg queue: 0.08
Episode: 230    Time(Min): 3.81 Max: 0.6       Min: 0.0      Avg queue: 0.08
Episode: 231    Time(Min): 3.83 Max: 0.6       Min: 0.0      Avg queue: 0.08
Episode: 232    Time(Min): 4.09 Max: 0.9       Min: 0.0      Avg queue: 0.09
Episode: 233    Time(Min): 4.11 Max: 0.9       Min: 0.0      Avg queue: 0.09
Episode: 234    Time(Min): 4.13 Max: 0.9       Min: 0.0      Avg queue: 0.09
Episode: 235    Time(Min): 4.19 Max: 0.9       Min: 0.0      Avg queue: 0.09
Episode: 236    Time(Min): 4.21 Max: 0.9       Min: 0.0      Avg queue: 0.09
Episode: 237    Time(Min): 4.24 Max: 0.9       Min: 0.0      Avg queue: 0.09
Episode: 238    Time(Min): 4.27 Max: 0.9       Min: 0.0      Avg queue: 0.09
Episode: 239    Time(Min): 4.3  Max: 0.9       Min: 0.0      Avg queue: 0.09
Episode: 240    Time(Min): 4.38 Max: 0.9       Min: 0.0      Avg queue: 0.1
Episode: 241    Time(Min): 4.47 Max: 0.9       Min: 0.0      Avg queue: 0.1
Episode: 242    Time(Min): 4.63 Max: 0.9       Min: 0.0      Avg queue: 0.1
Episode: 243    Time(Min): 4.65 Max: 0.9       Min: 0.0      Avg queue: 0.1
Episode: 244    Time(Min): 4.67 Max: 0.9       Min: 0.0      Avg queue: 0.1
Episode: 245    Time(Min): 4.71 Max: 0.9       Min: 0.0      Avg queue: 0.1
Episode: 246    Time(Min): 4.73 Max: 0.9       Min: 0.0      Avg queue: 0.11
Episode: 247    Time(Min): 4.76 Max: 0.9       Min: 0.0      Avg queue: 0.11
Episode: 248    Time(Min): 4.78 Max: 0.9       Min: 0.0      Avg queue: 0.11
Episode: 249    Time(Min): 4.88 Max: 0.9       Min: 0.0      Avg queue: 0.11
Episode: 250    Time(Min): 4.93 Max: 0.9       Min: 0.0      Avg queue: 0.11
Episode: 251    Time(Min): 4.95 Max: 0.9       Min: 0.0      Avg queue: 0.11
Episode: 252    Time(Min): 5.13 Max: 0.9       Min: 0.0      Avg queue: 0.12
Episode: 253    Time(Min): 5.19 Max: 0.9       Min: 0.0      Avg queue: 0.12
Episode: 254    Time(Min): 5.54 Max: 1.2       Min: 0.0      Avg queue: 0.13
Episode: 255    Time(Min): 5.56 Max: 1.2       Min: 0.0      Avg queue: 0.13
Episode: 256    Time(Min): 5.63 Max: 1.2       Min: 0.0      Avg queue: 0.13
Episode: 257    Time(Min): 5.65 Max: 1.2       Min: 0.0      Avg queue: 0.13
Episode: 258    Time(Min): 5.68 Max: 1.2       Min: 0.0      Avg queue: 0.13
```

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Episode: 259    Time(Min): 5.79 Max: 1.2        Min: 0.0         Avg queue: 0.14
Episode: 260    Time(Min): 5.86 Max: 1.2        Min: 0.0         Avg queue: 0.14
Episode: 261    Time(Min): 5.99 Max: 1.2        Min: 0.0         Avg queue: 0.14
Episode: 262    Time(Min): 6.17 Max: 1.2        Min: 0.0         Avg queue: 0.15
Episode: 263    Time(Min): 6.39 Max: 1.2        Min: 0.0         Avg queue: 0.16
Episode: 264    Time(Min): 6.42 Max: 1.2        Min: 0.0         Avg queue: 0.16
Episode: 265    Time(Min): 7.16 Max: 2.5        Min: 0.0         Avg queue: 0.18
Episode: 266    Time(Min): 7.39 Max: 2.5        Min: 0.0         Avg queue: 0.19
Episode: 267    Time(Min): 7.41 Max: 2.5        Min: 0.0         Avg queue: 0.19
Episode: 268    Time(Min): 7.44 Max: 2.5        Min: 0.0         Avg queue: 0.19
Episode: 269    Time(Min): 7.47 Max: 2.5        Min: 0.0         Avg queue: 0.19
Episode: 270    Time(Min): 7.5  Max: 2.5        Min: 0.0         Avg queue: 0.19
Episode: 271    Time(Min): 7.55 Max: 2.5        Min: 0.0         Avg queue: 0.19
Episode: 272    Time(Min): 7.58 Max: 2.5        Min: 0.0         Avg queue: 0.2
Episode: 273    Time(Min): 7.69 Max: 2.5        Min: 0.0         Avg queue: 0.2
Episode: 274    Time(Min): 7.83 Max: 2.5        Min: 0.0         Avg queue: 0.2
Episode: 275    Time(Min): 8.25 Max: 2.5        Min: 0.0         Avg queue: 0.22
Episode: 276    Time(Min): 8.37 Max: 2.5        Min: 0.0         Avg queue: 0.22
Episode: 277    Time(Min): 8.4  Max: 2.5        Min: 0.0         Avg queue: 0.22
Episode: 278    Time(Min): 8.92 Max: 2.5        Min: 0.0         Avg queue: 0.24
Episode: 279    Time(Min): 8.95 Max: 2.5        Min: 0.0         Avg queue: 0.24
Episode: 280    Time(Min): 9.72 Max: 2.6        Min: 0.0         Avg queue: 0.26
Episode: 281    Time(Min): 9.74 Max: 2.6        Min: 0.0         Avg queue: 0.26
Episode: 282    Time(Min): 9.79 Max: 2.6        Min: 0.0         Avg queue: 0.27
Episode: 283    Time(Min): 9.81 Max: 2.6        Min: 0.0         Avg queue: 0.27
Episode: 284    Time(Min): 9.93 Max: 2.6        Min: 0.0         Avg queue: 0.27
Episode: 285    Time(Min): 9.95 Max: 2.6        Min: 0.0         Avg queue: 0.27
Episode: 286    Time(Min): 9.98 Max: 2.6        Min: 0.0         Avg queue: 0.27
Episode: 287    Time(Min): 10.0 Max: 2.6        Min: 0.0         Avg queue: 0.27
Episode: 288    Time(Min): 10.02        Max: 2.6        Min: 0.0        Avg queue: 0.27
Episode: 289    Time(Min): 10.79        Max: 2.6        Min: 0.0        Avg queue: 0.29
Episode: 290    Time(Min): 10.81        Max: 2.6        Min: 0.0        Avg queue: 0.29
Episode: 291    Time(Min): 10.83        Max: 2.6        Min: 0.0        Avg queue: 0.29
Episode: 292    Time(Min): 11.35        Max: 2.6        Min: 0.0        Avg queue: 0.31
Episode: 293    Time(Min): 11.38        Max: 2.6        Min: 0.0        Avg queue: 0.31
Episode: 294    Time(Min): 11.4 Max: 2.6        Min: 0.0        Avg queue: 0.31
Episode: 295    Time(Min): 11.42        Max: 2.6        Min: 0.0        Avg queue: 0.31
Episode: 296    Time(Min): 11.45        Max: 2.6        Min: 0.0        Avg queue: 0.31
Episode: 297    Time(Min): 11.47        Max: 2.6        Min: 0.0        Avg queue: 0.31
Episode: 298    Time(Min): 12.22        Max: 2.6        Min: 0.0        Avg queue: 0.34
Episode: 299    Time(Min): 12.25        Max: 2.6        Min: 0.0        Avg queue: 0.33
Episode: 300    Time(Min): 13.03        Max: 2.6        Min: 0.0        Avg queue: 0.36
Episode: 301    Time(Min): 13.06        Max: 2.6        Min: 0.0        Avg queue: 0.36
```

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Episode: 302     Time(Min): 13.83       Max: 2.6       Min: 0.0       Avg queue: 0.38
Episode: 303     Time(Min): 14.49       Max: 2.6       Min: 0.0       Avg queue: 0.4
Episode: 304     Time(Min): 14.52       Max: 2.6       Min: 0.0       Avg queue: 0.4
Episode: 305     Time(Min): 14.54       Max: 2.6       Min: 0.0       Avg queue: 0.4
Episode: 306     Time(Min): 14.81       Max: 2.6       Min: 0.0       Avg queue: 0.41
Episode: 307     Time(Min): 15.0 Max: 2.6       Min: 0.0       Avg queue: 0.41
Episode: 308     Time(Min): 15.38       Max: 2.6       Min: 0.0       Avg queue: 0.42
Episode: 309     Time(Min): 15.4 Max: 2.6       Min: 0.0       Avg queue: 0.42
Episode: 310     Time(Min): 15.63       Max: 2.6       Min: 0.0       Avg queue: 0.43
Episode: 311     Time(Min): 16.42       Max: 2.6       Min: 0.0       Avg queue: 0.46
Episode: 312     Time(Min): 16.44       Max: 2.6       Min: 0.0       Avg queue: 0.46
Episode: 313     Time(Min): 16.46       Max: 2.6       Min: 0.0       Avg queue: 0.46
Episode: 314     Time(Min): 16.49       Max: 2.6       Min: 0.0       Avg queue: 0.46
Episode: 315     Time(Min): 16.51       Max: 2.6       Min: 0.0       Avg queue: 0.46
Episode: 316     Time(Min): 16.54       Max: 2.6       Min: 0.0       Avg queue: 0.46
Episode: 317     Time(Min): 16.68       Max: 2.6       Min: 0.0       Avg queue: 0.46
Episode: 318     Time(Min): 16.7 Max: 2.6       Min: 0.0       Avg queue: 0.46
Episode: 319     Time(Min): 17.49       Max: 2.6       Min: 0.0       Avg queue: 0.49
Episode: 320     Time(Min): 17.51       Max: 2.6       Min: 0.0       Avg queue: 0.49
Episode: 321     Time(Min): 17.54       Max: 2.6       Min: 0.0       Avg queue: 0.48
Episode: 322     Time(Min): 18.32       Max: 2.6       Min: 0.0       Avg queue: 0.51
Completed!
CPU times: user 17min 9s, sys: 38.8 s, total: 17min 48s
Wall time: 18min 19s
```
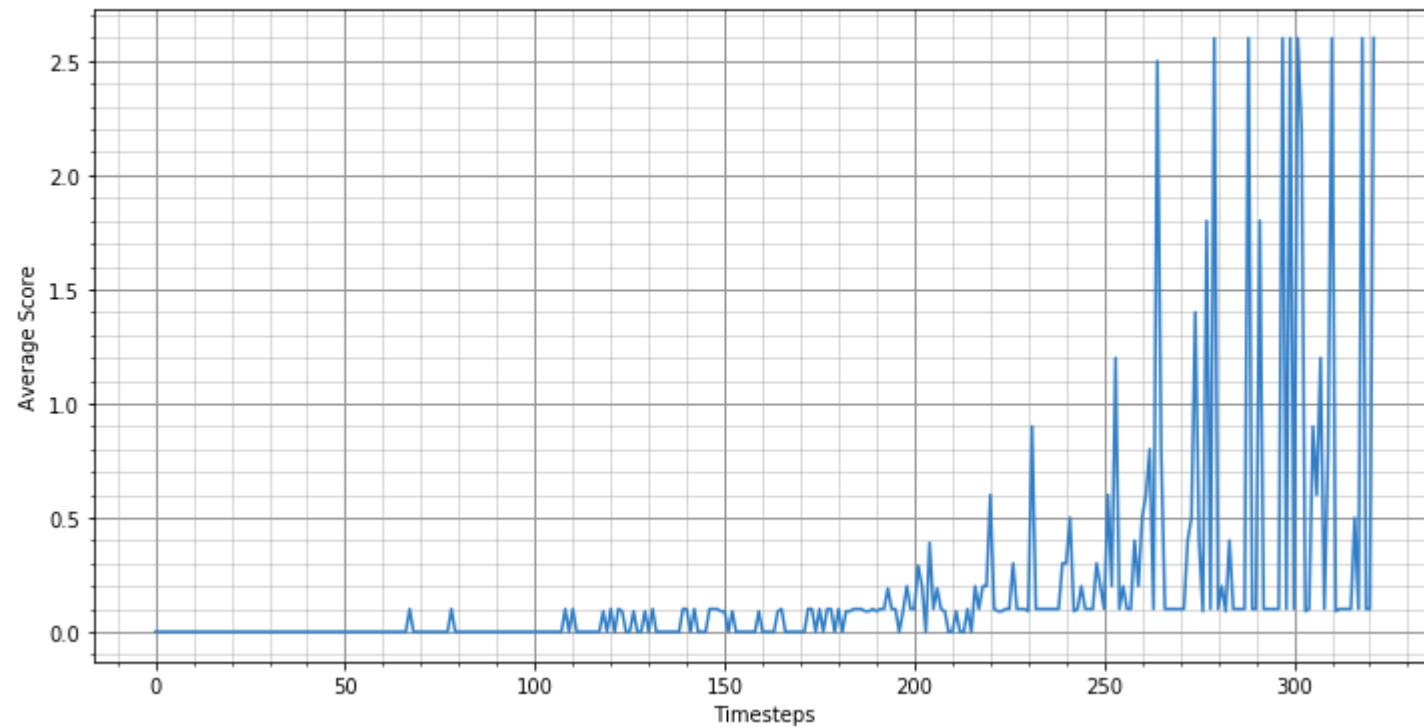
```
In [10]:  def plot_results(scores):
              fig, ax = plt.subplots(figsize=(12, 6))
              fig.suptitle("Rewards", fontsize=15)
              ax.plot(scores, color="#307EC7", label="line")
              ax.set_xlabel("Timesteps")
              ax.set_ylabel("Average Score")
              # GRID
              ax.grid(True)
              ax.grid(b=True, which='major', color='#999999', linestyle='-', linewidth=1)
              ax.minorticks_on()
              ax.grid(b=True, which='minor', color='#999999', linestyle='-', alpha=0.7,linewidth=0.5)
              fig.savefig("learning.jpg")

          plot_results(results)
```