5x5 Grid World

Monte Carlo Method 를 적용하여 5x5 Grid World 에 대한 Q 함수를 시각화하고 및 policy 를 구하라.

(1) 파라메터 ε 을 변경하며 결과 비교

(2) 파라메터 α 를 변경하며 결과 비교

GridWorld class

In [22]:

```python
import numpy as np
import common.gridworld5_render as render_helper

class GridWorld:
    def __init__(self):
        self.action_space = [0, 1, 2, 3]  # 행동 공간(가능한 행동들)
        self.action_meaning = {  # 행동의 의미
            0: "UP",
            1: "DOWN",
            2: "LEFT",
            3: "RIGHT",
        }

        self.reward_map = np.array(  # 보상 맵(각 좌표의 보상 값)
            [[0, 0, 0, -1.0, 1.0],
             [0, 0, 0, 0, 0],
             [0, None, None, 0, 0],
             [0, 0, 0, 0, -1.0],
             [0, 0, 0, 0, 0]
             ]
        )

        self.goal_state = (0, 4)     # 목표 상태(좌표)
        self.wall_state = [(2, 1), (2,2)]   # 2,1 2,2 # 벽 상태(좌표)
        self.start_state = (4, 0)    # 시작 상태(좌표)
        self.agent_state = self.start_state   # 에이전트 초기 상태(좌표)

    @property
    def height(self):
        return len(self.reward_map)

    @property
    def width(self):
        return len(self.reward_map[0])

    @property
    def shape(self):
        return self.reward_map.shape

    def actions(self):
        return self.action_space

    def states(self):
        for h in range(self.height):
            for w in range(self.width):
                yield (h, w)
```

```
    def next_state(self, state, action):
        # 이동 위치 계산
        action_move_map = [(-1, 0), (1, 0), (0, -1), (0, 1)]
        move = action_move_map[action]
        next_state = (state[0] + move[0], state[1] + move[1])
        ny, nx = next_state

        # 이동한 위치가 그리드 월드의 테두리 밖이나 벽인가?
        if nx < 0 or nx >= self.width or ny < 0 or ny >= self.heigh
            next_state = state
        elif next_state == self.wall_state[0] or next_state == self
            next_state = state

        return next_state  # 다음 상태 반환

    def reward(self, state, action, next_state):
        if self.reward_map[next_state] == None:
            return 0

        return self.reward_map[next_state]

    def reset(self):
        self.agent_state = self.start_state
        return self.agent_state

    def step(self, action):
        state = self.agent_state
        next_state = self.next_state(state, action)
        reward = self.reward(state, action, next_state)
        done = (next_state == self.goal_state)

        self.agent_state = next_state
        return next_state, reward, done

    def render_v(self, v=None, policy=None, print_value=True):
        renderer = render_helper.Renderer(self.reward_map, self.goa
                                          self.wall_state)
        renderer.render_v(v, policy, print_value)

    def render_q(self, q=None, print_value=True):
        renderer = render_helper.Renderer(self.reward_map, self.goa
                                          self.wall_state)
        renderer.render_q(q, print_value)
```

Policy Evaluation

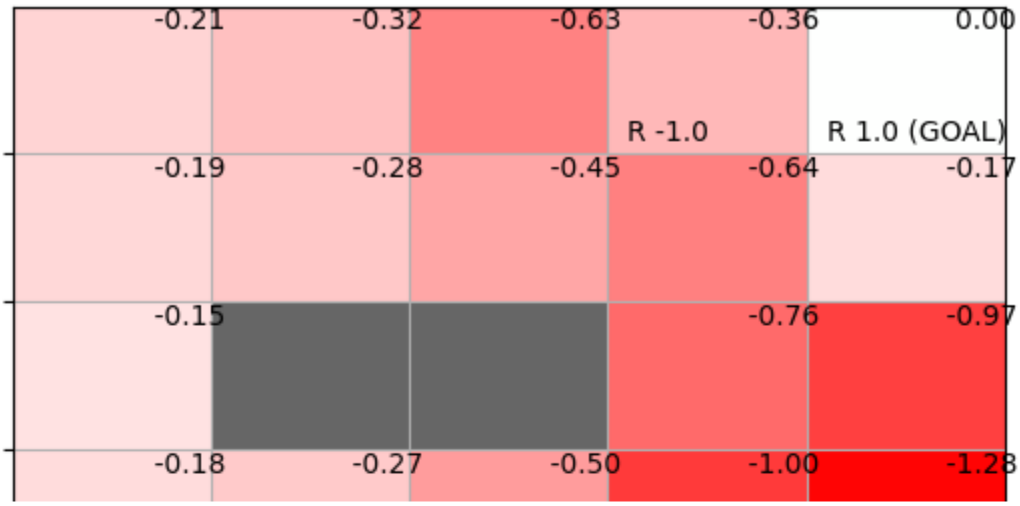
In [26]:

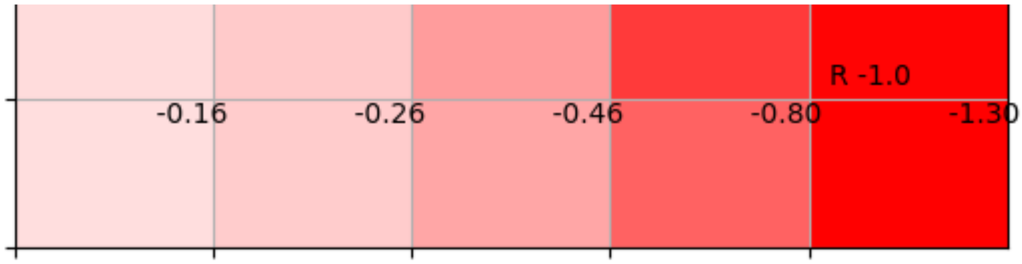
```
from collections import defaultdict
import numpy as np

class RandomAgent:
    def __init__(self):
        self.gamma = 0.9
        self.batch_size = 4

        random_actions = {0: 0.25, 1:0.25, 2:0.25, 3:0.25}
        self.pi = defaultdict(lambda: random_actions)
        self.V = defaultdict(lambda: 0)
        self.cnts = defaultdict(lambda: 0)
        self.memory = []

    def get_action(self, state):
```

```python
    def get_action(self, state):
        action_probs = self.pi[state]
        actions = list(action_probs.keys())
        probs = list(action_probs.values())
        return np.random.choice(actions, p=probs)

    def add(self, state, action, reward):
        data = [state, action, reward]
        self.memory.append(data)

    def reset(self):
        self.memory.clear()

    def eval(self):
        G = 0
        for data in reversed(self.memory):  # 역방향으로(reversed) 따라
            state, action, reward = data
            G = self.gamma * G + reward
            self.cnts[state] += 1
            self.V[state] += (G - self.V[state]) / self.cnts[state]
```

In [27]:

```python
env = GridWorld()
agent = RandomAgent()

episodes = 1000
for episode in range(episodes):
    state = env.reset()
    agent.reset()

    while True:
        action = agent.get_action(state)       # 행동 선택
        next_state, reward, done = env.step(action)  # 행동 수행

        agent.add(state, action, reward)       # (상태, 행동, 보상) 저

        if done:  # 목표에 도달 시
            agent.eval()  # 몬테카를로 방식으로 가치 함수 갱신
            break         # 다음 에피소드 시작

        state = next_state


env.render_v(agent.V)
```





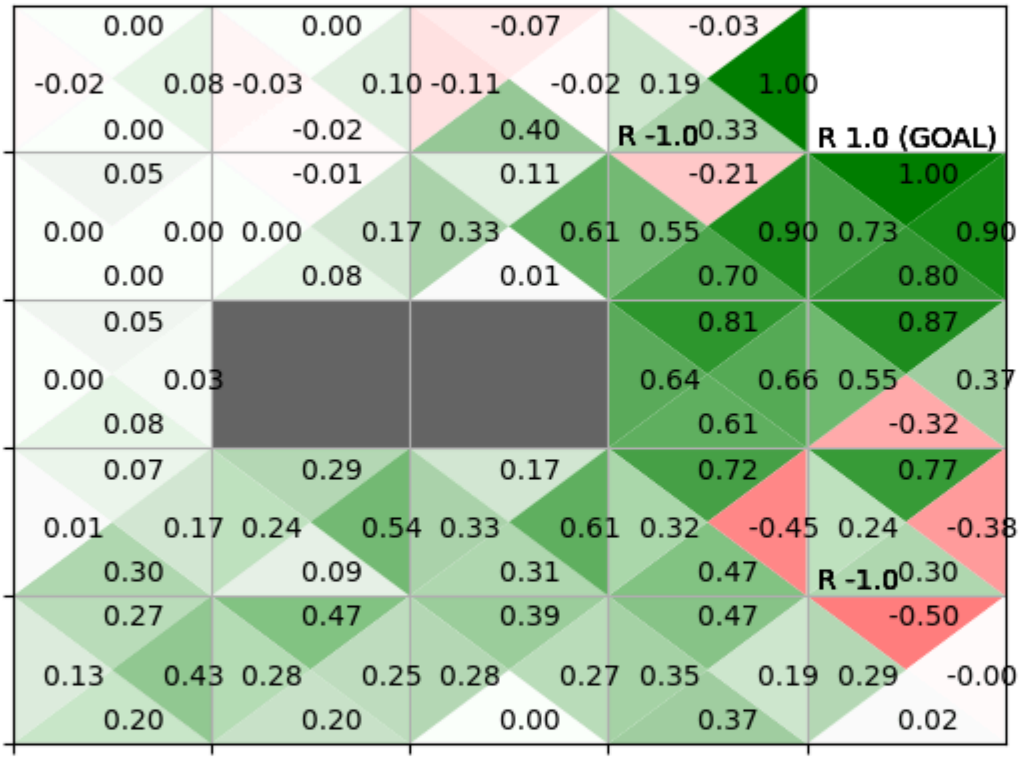
Policy control

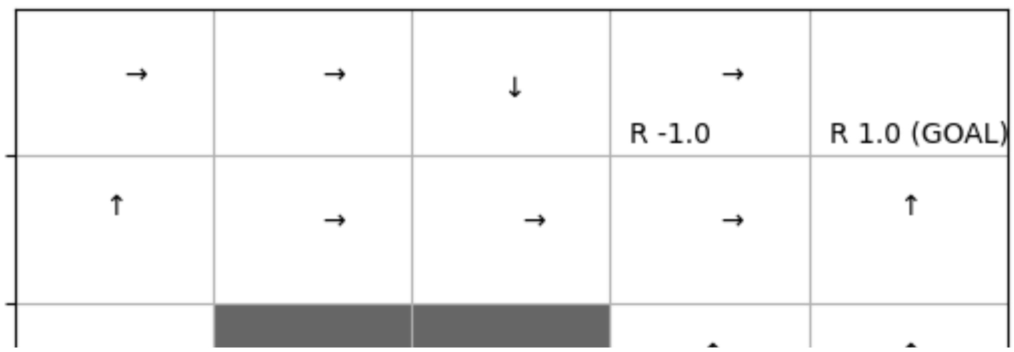
In [30]:

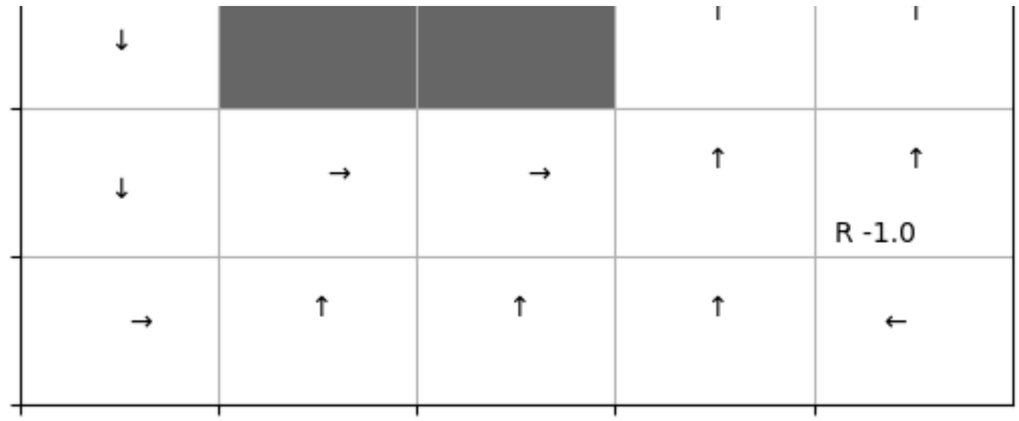
```
import numpy as np
from collections import defaultdict
#from common.gridworld import GridWorld

def greedy_probs(Q, state, epsilon=0, action_size=4):
    qs = [Q[(state, action)] for action in range(action_size)]
    max_action = np.argmax(qs)

    base_prob = epsilon / action_size
    action_probs = {action: base_prob for action in range(action_si
    action_probs[max_action] += (1 - epsilon)
    return action_probs


class McAgent:
    def __init__(self, gamma=0.9, epsilon=0.1, alpha=0.1, action_si
        self.gamma = gamma
        self.epsilon = epsilon
        self.alpha = alpha
        self.action_size = action_size

        random_actions = {0:0.25, 1:0.25, 2:0.25, 3:0.25}
        self.pi = defaultdict(lambda: random_actions)
        self.Q = defaultdict(lambda: 0)

        self.memory = []

    def get_action(self, state):
        action_probs = self.pi[state]
        actions = list(action_probs.keys())
        probs = list(action_probs.values())
        return np.random.choice(actions, p=probs)

    def add(self, state, action, reward):
        data = (state, action, reward)
        self.memory.append(data)

    def reset(self):
        self.memory.clear()

    def update(self):
        G = 0
        for data in reversed(self.memory):
            state, action, reward = data
            G = self.gamma * G + reward
            key = (state, action)

            self.Q[key] += (G-self.Q[key]) * self.alpha
            self.pi[state] = greedy_probs(self.Q, state, self.epsil
```

In [33]:

```
env = GridWorld()

# Parameters
gamma = 0.9
epsilon = 0.1
alpha = 0.1
action_size = 4
agent = McAgent(gamma, epsilon, alpha, action_size)

episodes = 10000
for episode in range(episodes):
    state = env.reset()
    agent.reset()

    while True:
        action = agent.get_action(state)
        next_state, reward, done = env.step(action)

        agent.add(state, action, reward)
        if done:
            agent.update()
            break

        state = next_state

env.render_q(agent.Q)
```





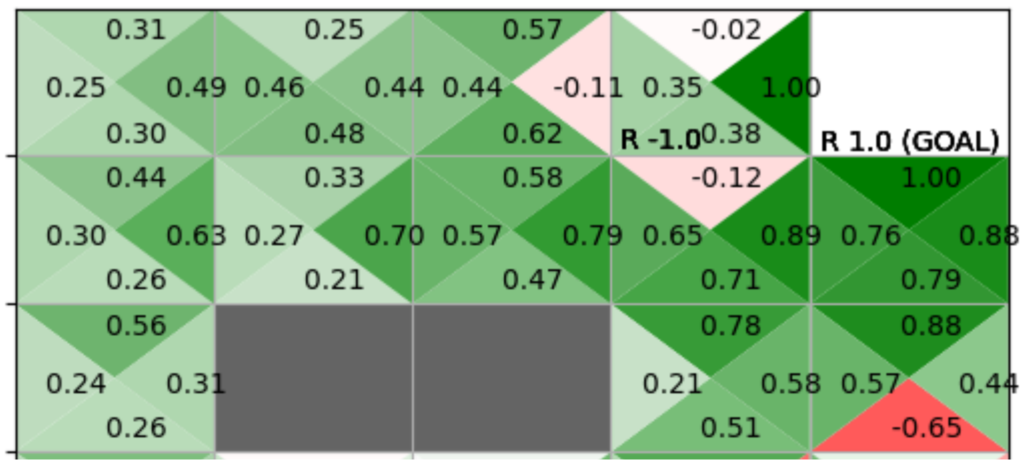


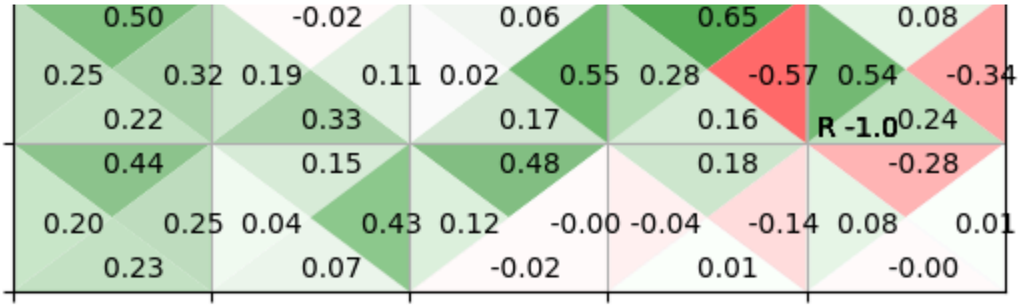
epsilon, alpha 값에 따른 결과 비교

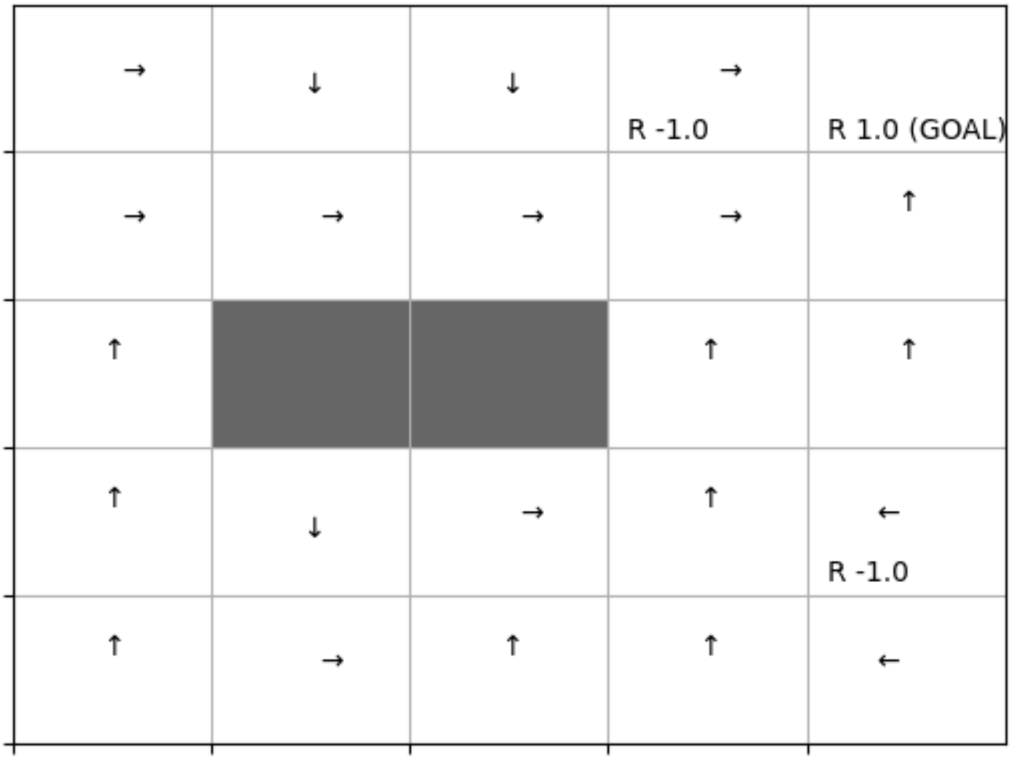
In [34]:

```
# Parameters
epsilon_values = [0.1, 0.3, 0.5]
alpha_values = [0.1, 0.3, 0.5]
episodes = 10000

for epsilon in epsilon_values:
    for alpha in alpha_values:
        env = GridWorld()
        agent = McAgent(gamma=0.9, epsilon=epsilon, alpha=alpha, ac

        for episode in range(episodes):
            state = env.reset()
            agent.reset()

            while True:
                action = agent.get_action(state)
                next_state, reward, done = env.step(action)
                agent.add(state, action, reward)

                if done:
                    agent.update()
                    break

                state = next_state

        # Visualization
        print(f"Epsilon={epsilon}, Alpha={alpha}")
        env.render_q(agent.Q)
```

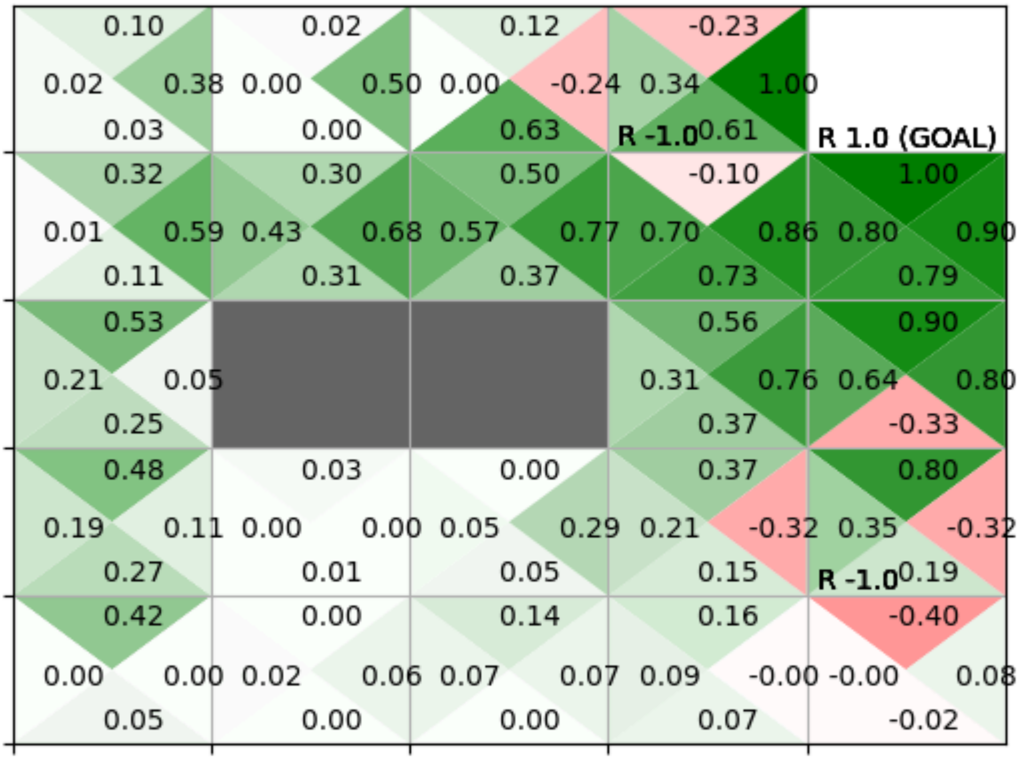
```
Epsilon=0.1, Alpha=0.1
```

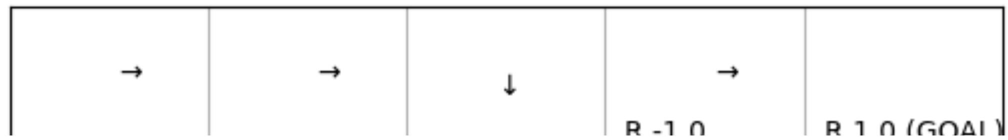


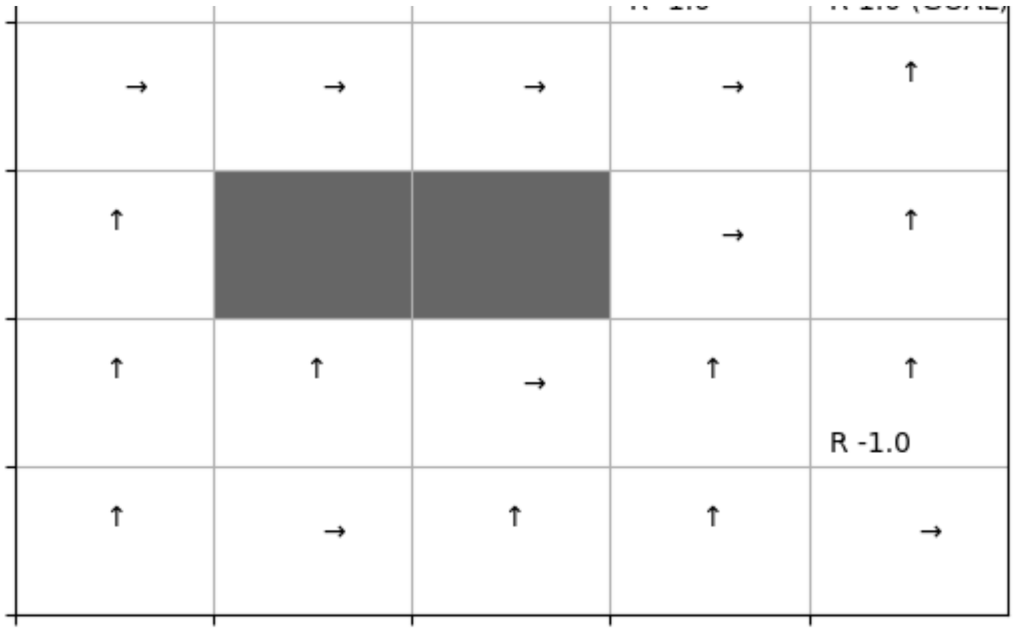




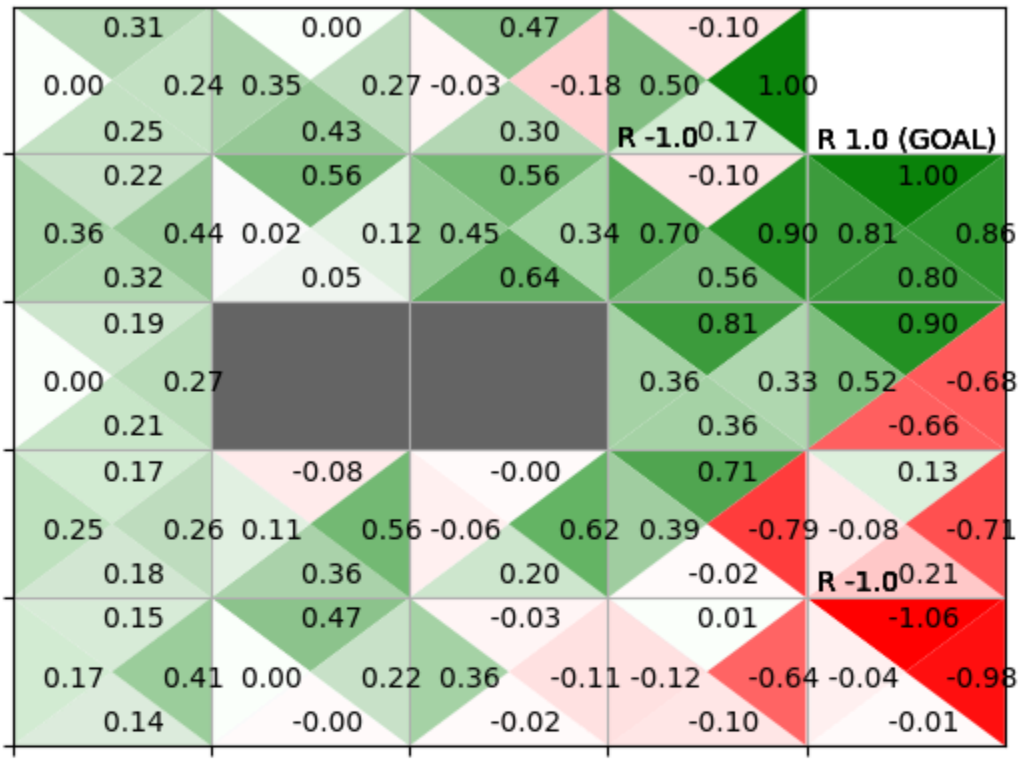
Epsilon=0.1, Alpha=0.3

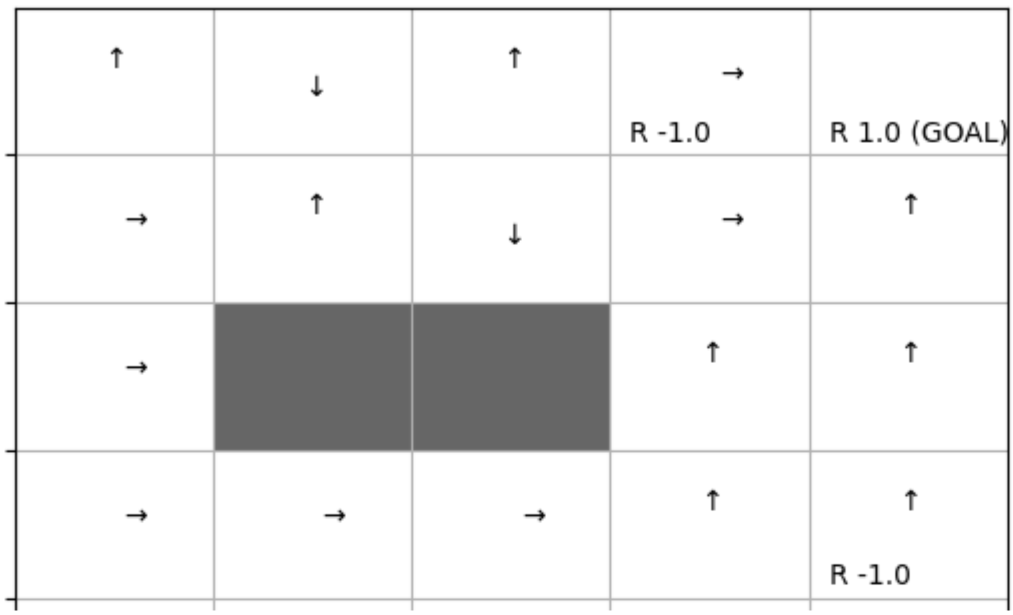


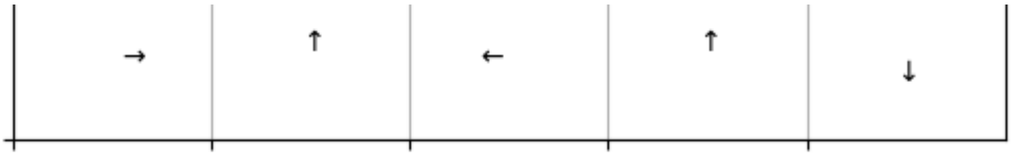




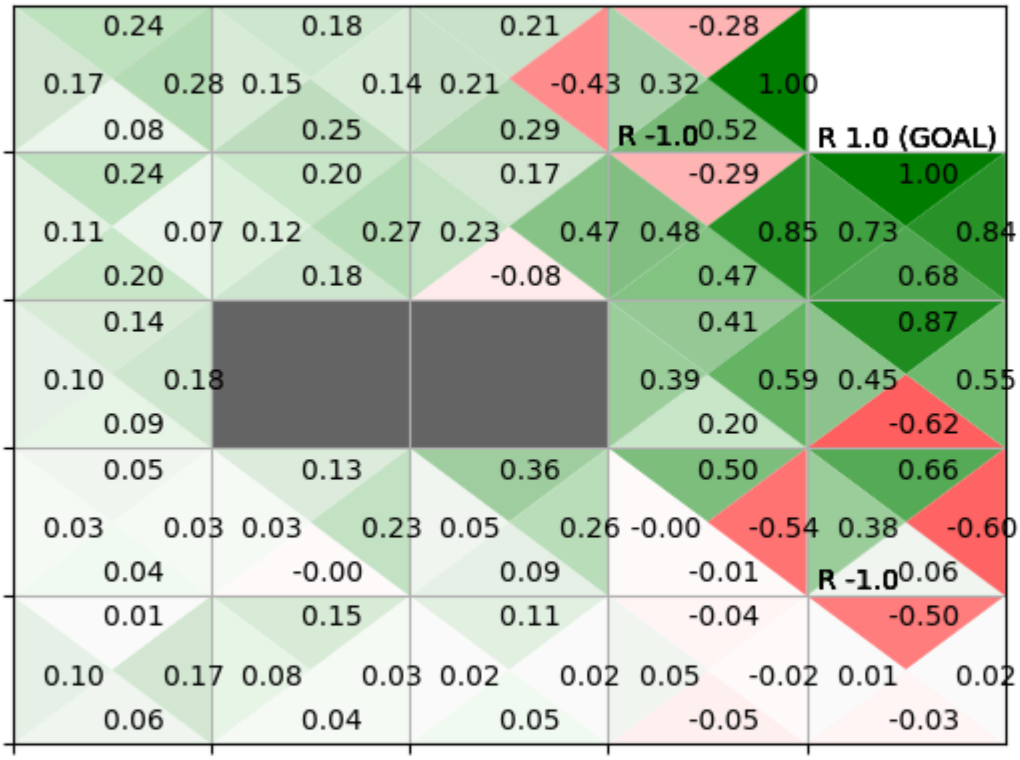
Epsilon=0.1, Alpha=0.5

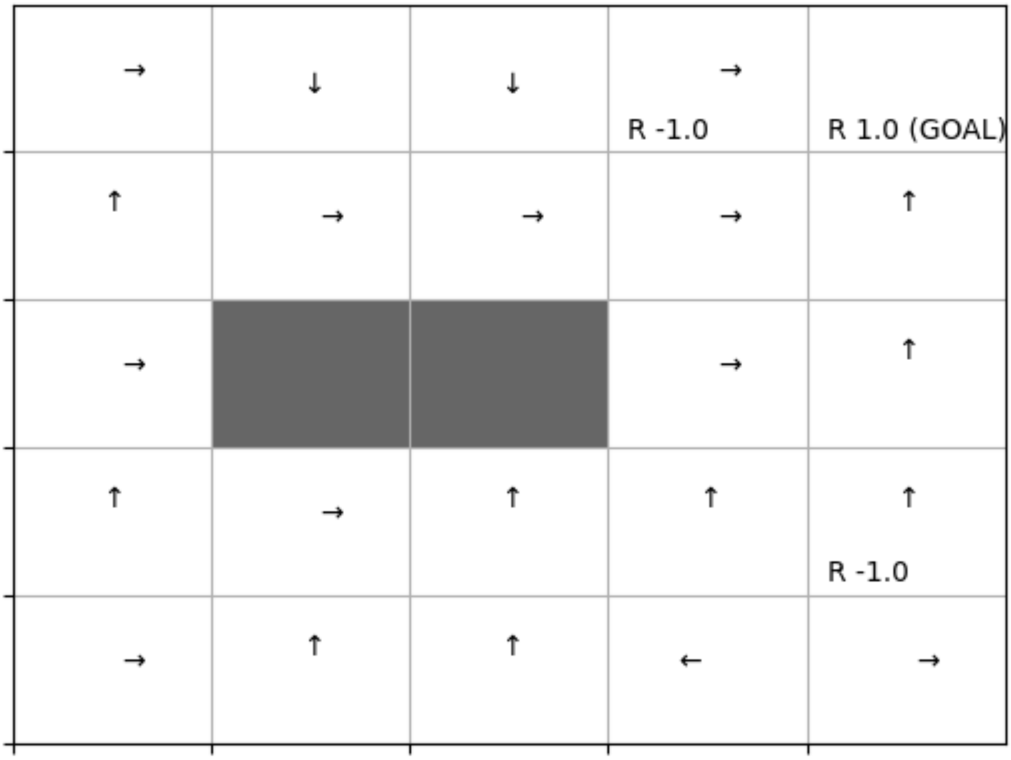




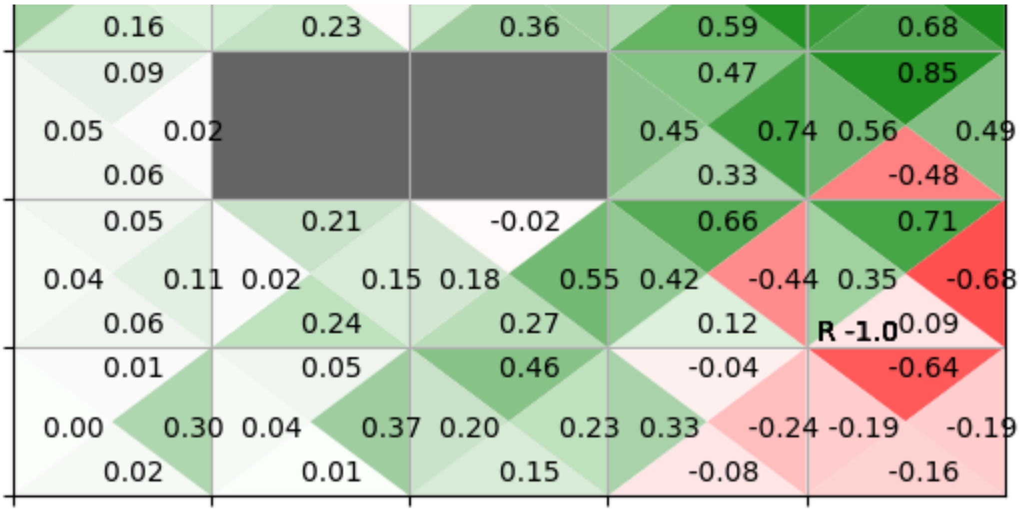


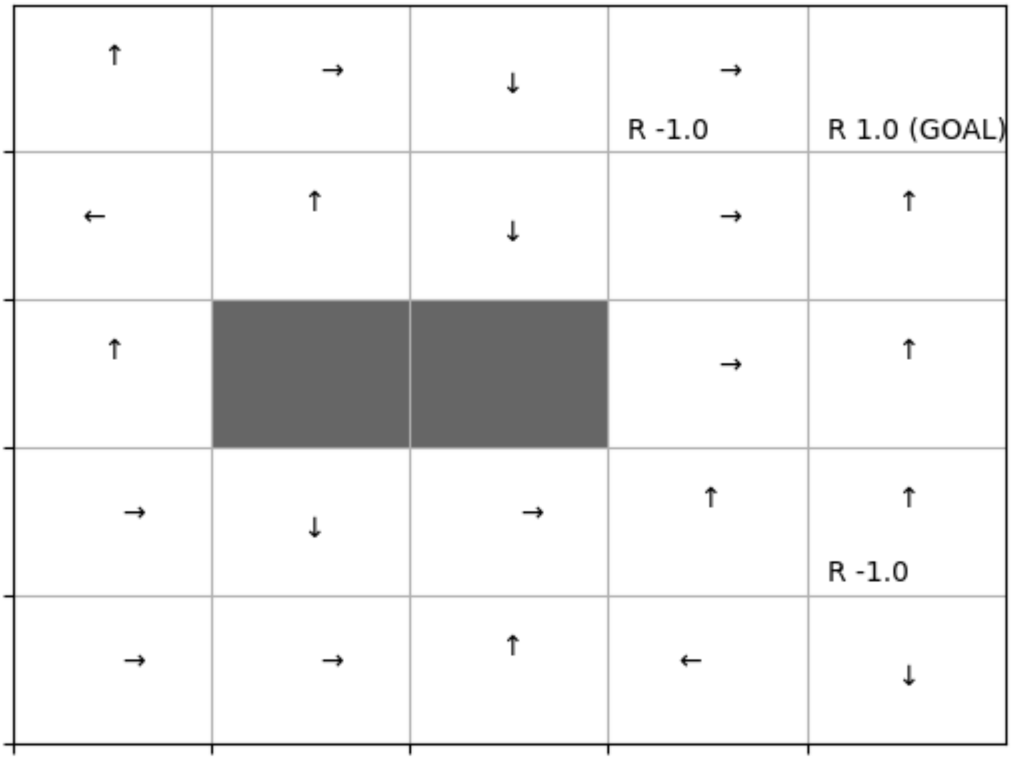
Epsilon=0.3, Alpha=0.1



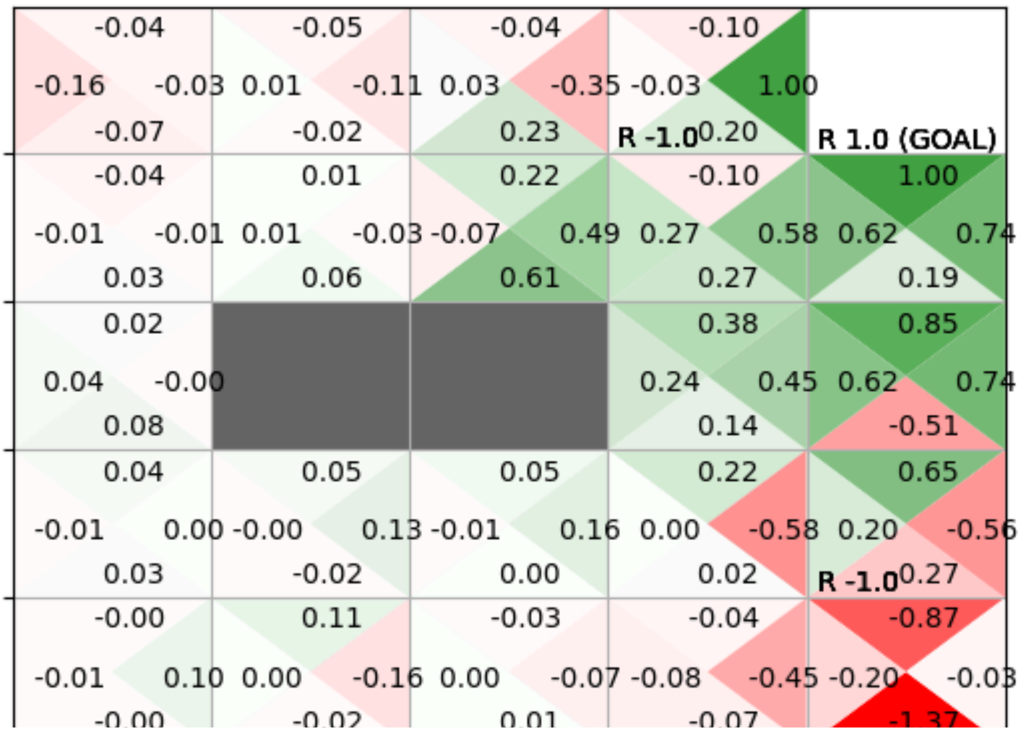


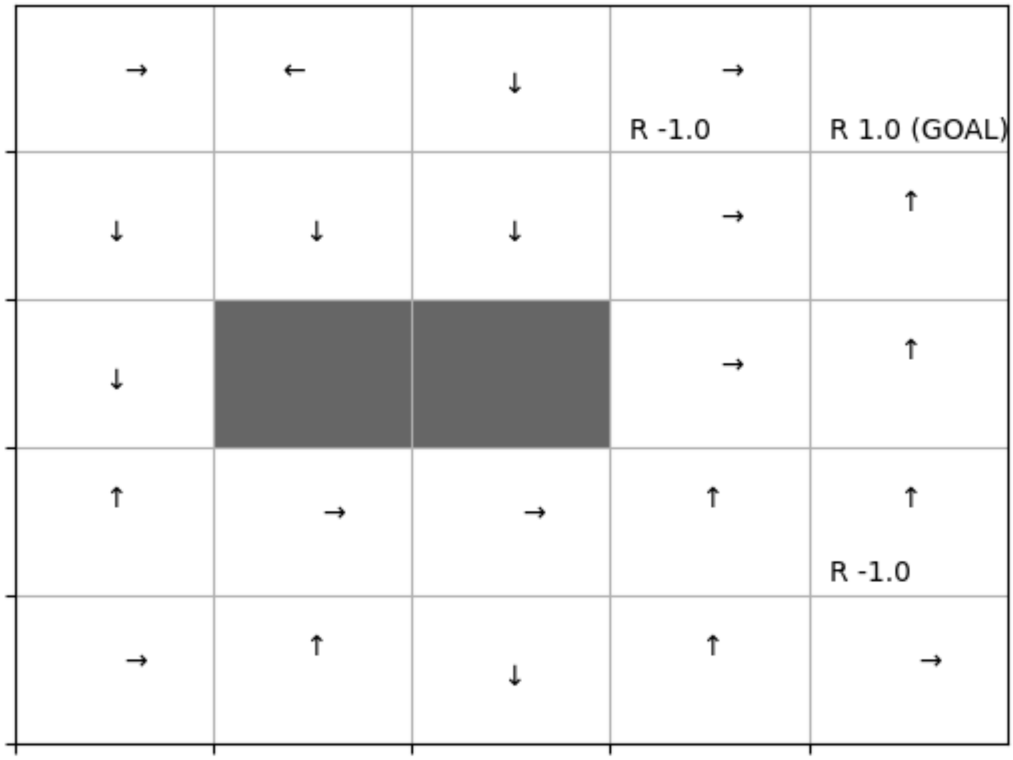
Epsilon=0.3, Alpha=0.3



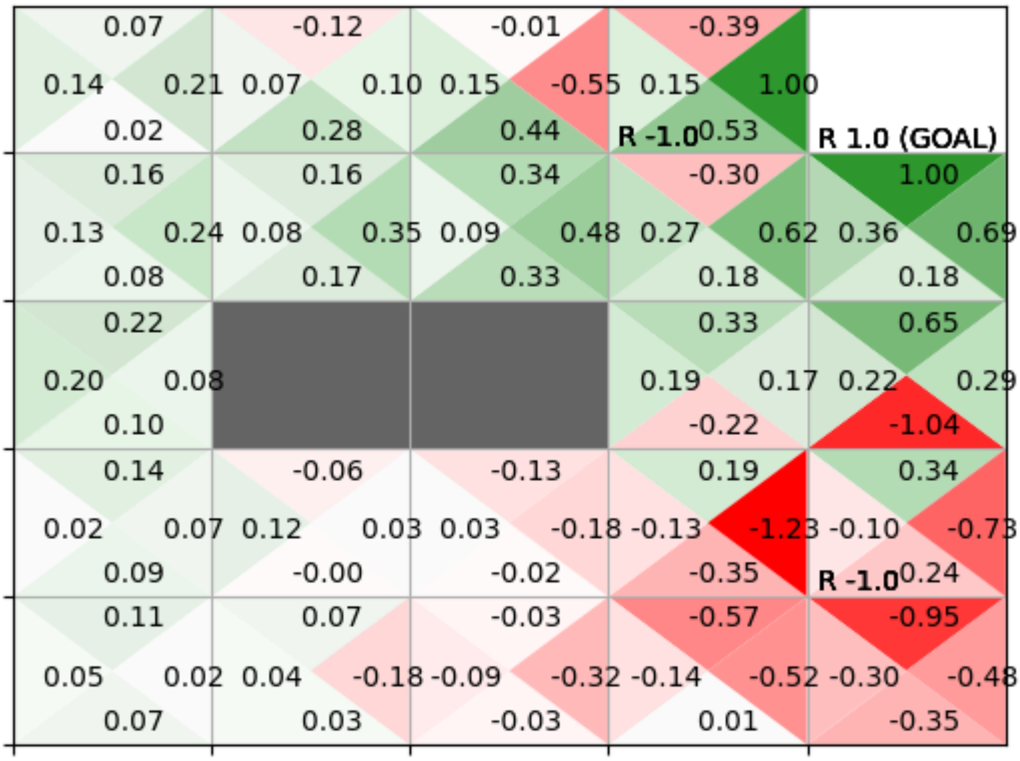


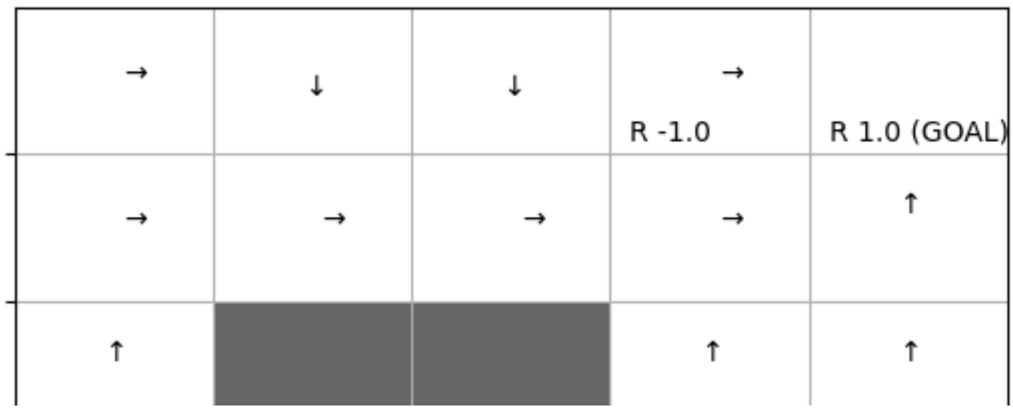
Epsilon=0.3, Alpha=0.5

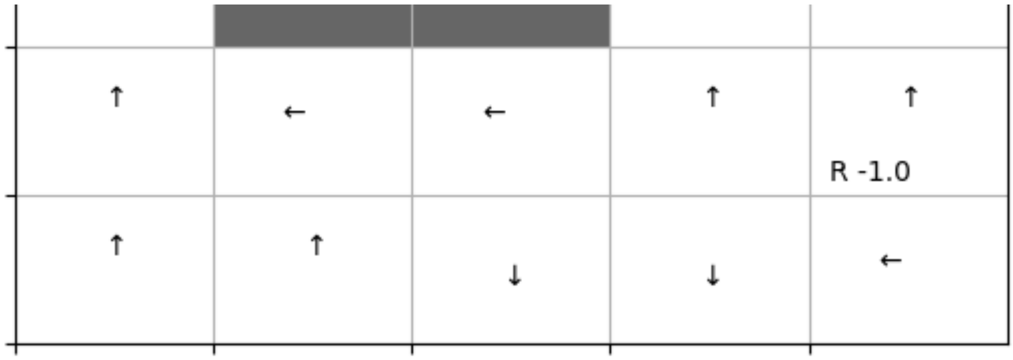




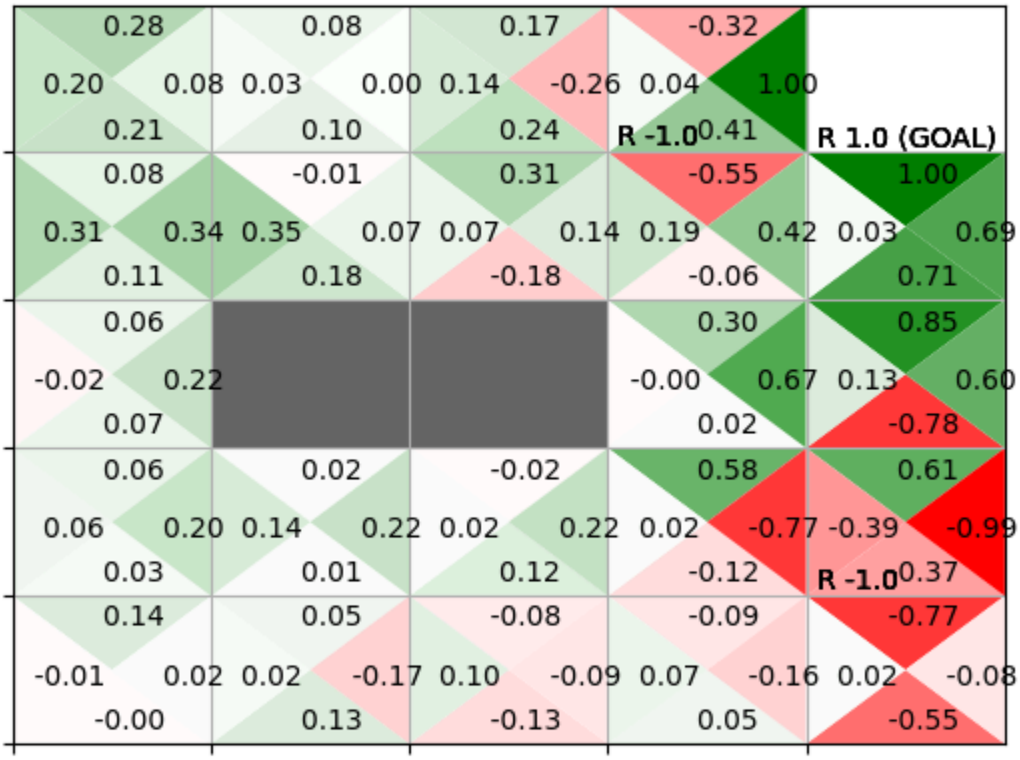
`Epsilon=0.5, Alpha=0.1`

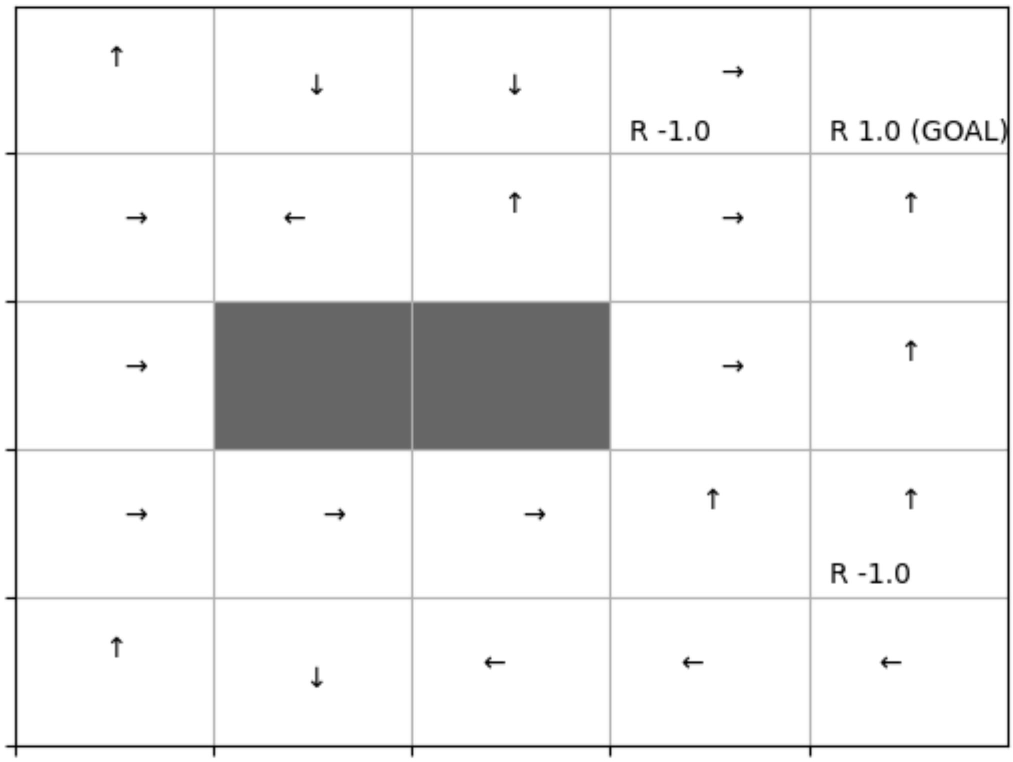




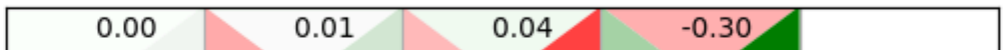


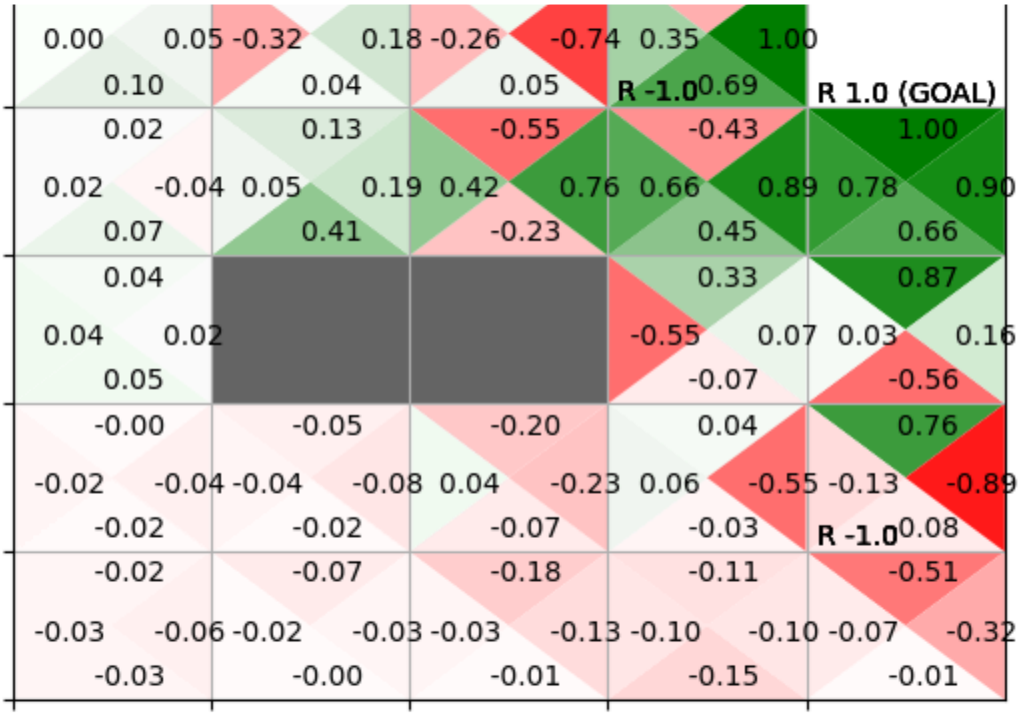
Epsilon=0.5, Alpha=0.3

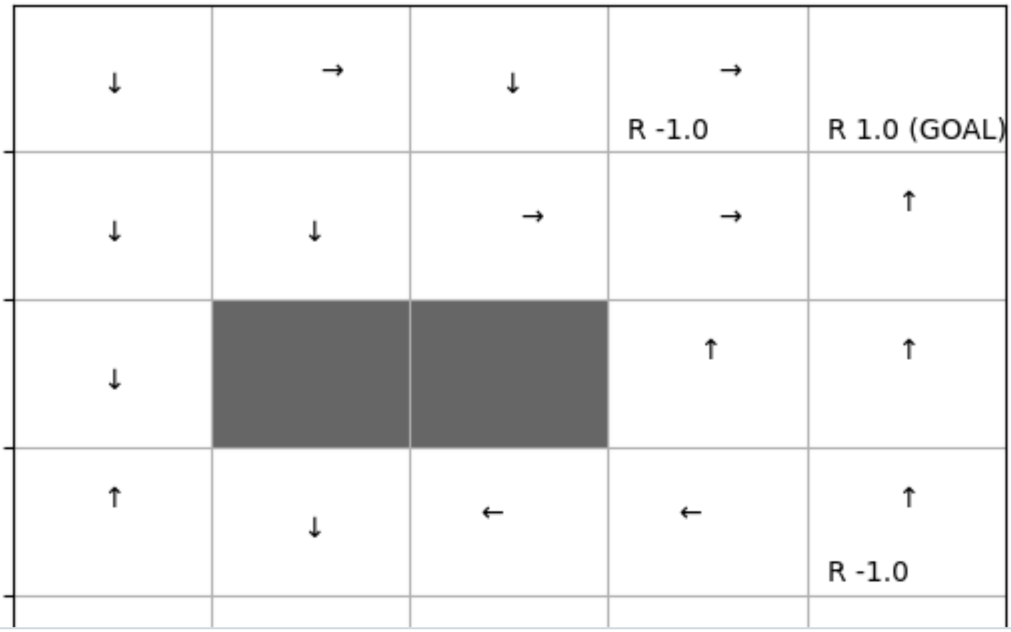




Epsilon=0.5, Alpha=0.5




0.00 0.05 -0.32 0.18 -0.26 -0.74 0.35 1.00
0.10 0.04 0.05 R -1.0 0.69 R 1.0 (GOAL)
0.02 0.13 -0.55 -0.43 1.00
0.02 -0.04 0.05 0.19 0.42 0.76 0.66 0.89 0.78 0.90
0.07 0.41 -0.23 0.45 0.66
0.04 0.33 0.87
0.04 0.02 -0.55 0.07 0.03 0.16
0.05 -0.07 -0.56
-0.00 -0.05 -0.20 0.04 0.76
-0.02 -0.04 -0.04 -0.08 0.04 -0.23 0.06 -0.55 -0.13 -0.89
-0.02 -0.02 -0.07 -0.03 R -1.0 0.08
-0.02 -0.07 -0.18 -0.11 -0.51
-0.03 -0.06 -0.02 -0.03 -0.03 -0.13 -0.10 -0.10 -0.07 -0.32
-0.03 -0.00 -0.01 -0.15 -0.01


↓ → ↓ →
R -1.0
R 1.0 (GOAL)
↓ ↓ → → ↑
↓ ↑ ↑
↑ ↓ ← ← ↑
R -1.0