AV Behavior in ghost_cutin with Reduced Friction

In [1]:
```
import os
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
# %matplotlib inline
import scipy.stats
from scipy.stats import norm, binom, poisson
from dtaidistance import dtw

import json
```

Testing Parameters

- cloudiness = 100
- precipitation = 100
- **precipitation_deposits = 100**
- sun_altitude_angle = 5
- sun_azimuth_angle = 0
- **wetness = 100**
- fog_density = 30
- wind_intensity = 70

Reduced Friction Setup

Layered folders, parse into 2d lists of dicts

In [2]:
```
import os

txt_lists = []
for root, dirs, files in os.walk("./Data/Friction Rain"):
    for file in files:
        if file.endswith(".txt"):
             with open(os.path.join(root, file), encoding = 'utf-8') as f:
                read_string = f.read()
                json_object = json.loads(read_string)
                txt_lists.append(json_object)
```

Examining results

In [3]:
```
count = 0
for txt in txt_lists:
    if txt['_checkpoint']['records'][0]['status'] == 'Completed':
        count += 1
```

```
print("Average complete ratio:", count/100)
```

```
Average complete ratio: 1.0
```

In [4]:
```
count = 0
for txt in txt_lists:
    count += txt['_checkpoint']['records'][0]['scores']['score_route']
print("Average score route:", count/100)
```

```
Average score route: 100.0
```

Setting up into 2d lists of DataFrames

In [5]:
```
df_array = np.empty(100, dtype=object)

for i in range(len(df_array)):
    df_array[i] = pd.DataFrame()
```

In [6]:
```
dir_path = './Data/Friction Rain'

# list to store files
res = []

# Iterate directory
run_index = 0
for path in os.listdir(dir_path):
    # check if current path is a file
    if not os.path.isfile(os.path.join(dir_path, path)):
        df = pd.DataFrame()
        for file in os.listdir(os.path.join(dir_path, path)):
            file_path = os.path.join(dir_path, os.path.join(path, file))

            if "_ctl.csv" in file_path:
                df = pd.read_csv(file_path)
            elif "_cvip.csv" in file_path:
                temp = pd.read_csv(file_path)
                df = pd.concat([df, temp], axis=1)
            elif "_traj.csv" in file_path:
                temp = pd.read_csv(file_path)
                df = pd.concat([df, temp], axis=1)

        df_array[run_index] = df
        run_index += 1
```

In [7]:
```
df_array[0]
```

Out[7]:

	ts	agent_id	throttle	steer	brake	ts	agent_id	cvip	cvip_x	cvi
0	291905	0	0.900000	-0.021996	0.0	291905	0	500.497261	198.767441	-95.832
1	291906	0	0.900000	-0.003608	0.0	291906	0	5.598742	195.567444	-90.832
2	291907	0	0.900000	-0.003004	0.0	291907	0	5.595580	195.567444	-90.832
3	291908	0	0.900000	-0.001938	0.0	291908	0	5.592744	195.567444	-90.832
4	291909	0	0.900000	-0.000677	0.0	291909	0	5.590235	195.567444	-90.832
...	...	...	...	...	...	...	...	...	...	
787	292692	0	0.464959	-0.004117	0.0	292692	0	50.645825	192.611008	93.792
788	292693	0	0.443359	-0.003297	0.0	292693	0	50.757453	192.607147	94.124
789	292694	0	0.300473	-0.003195	0.0	292694	0	50.869303	192.603271	94.456
790	292695	0	0.388461	-0.002975	0.0	292695	0	50.981369	192.599426	94.788
791	292696	0	0.464979	-0.002496	0.0	292696	0	51.093649	192.595566	95.121

792 rows × 17 columns

Unmodified Friction Setup

Layered folders, parse into 2d lists of dicts

In [8]:
```
txt_lists_orig = []
for root, dirs, files in os.walk("./Data/Rain/Simulations Rain PC/campaign_results_new
    for file in files:
        if file.endswith(".txt"):
             with open(os.path.join(root, file), encoding = 'utf-8') as f:
                read_string = f.read()
                json_object = json.loads(read_string)
                txt_lists_orig.append(json_object)
```

Examining results

In [9]:
```
count = 0
for txt in txt_lists_orig:
    if txt['_checkpoint']['records'][0]['status'] == 'Completed':
        count += 1

print("Average complete ratio:",count/100)
```

```
Average complete ratio: 1.0
```

In [10]:
```
count = 0
for txt in txt_lists_orig:
    count += txt['_checkpoint']['records'][0]['scores']['score_route']
print("Average score route:",count/100)
```

```
Average score route: 100.0
```

Setting up into 2d lists of DataFrames

In [11]:
```
df_array_orig = np.empty(100, dtype=object)

for i in range(len(df_array_orig)):
    df_array_orig[i] = pd.DataFrame()
```

In [12]:
```
dir_path = './Data/Rain/Simulations Rain PC/campaign_results_new/route_highway_epoch24

# list to store files
res = []

# Iterate directory
run_index = 0
for path in os.listdir(dir_path):
    # check if current path is a file
    if not os.path.isfile(os.path.join(dir_path, path)):
        df = pd.DataFrame()
        for file in os.listdir(os.path.join(dir_path, path)):
            file_path = os.path.join(dir_path, os.path.join(path, file))

            if "_ctl.csv" in file_path:
                df = pd.read_csv(file_path)
            elif "_cvip.csv" in file_path:
                temp = pd.read_csv(file_path)
                df = pd.concat([df, temp], axis=1)
            elif "_traj.csv" in file_path:
                temp = pd.read_csv(file_path)
                df = pd.concat([df, temp], axis=1)

        df_array_orig[run_index] = df
        run_index += 1
```

In [13]:
```
df_array_orig[0]
```

Out[13]:

	ts	agent_id	throttle	steer	brake	ts	agent_id	cvip	cvip_x	c
0	2177908	0	0.900000	-0.019394	0.0	2177908	0	500.491189	198.767441	-95.8
1	2177909	0	0.900000	-0.002667	0.0	2177909	0	5.595580	195.567444	-90.8
2	2177910	0	0.900000	-0.004700	0.0	2177910	0	5.592365	195.567444	-90.8
3	2177911	0	0.900000	0.003541	0.0	2177911	0	5.589578	195.567444	-90.8
4	2177912	0	0.900000	-0.000345	0.0	2177912	0	5.587154	195.567444	-90.8
...	...	...	...	...	...	...	...	...	...	
756	2178664	0	0.417004	-0.001579	0.0	2178664	0	56.217592	192.540756	99.2
757	2178665	0	0.329465	-0.001539	0.0	2178665	0	56.325781	192.534561	99.5
758	2178666	0	0.284043	-0.001386	0.0	2178666	0	56.434533	192.527802	99.8
759	2178667	0	0.269944	-0.001319	0.0	2178667	0	56.543857	192.520477	100.2
760	2178668	0	0.480651	-0.001058	0.0	2178668	0	56.653767	192.512665	100.5

761 rows × 17 columns

Comparison

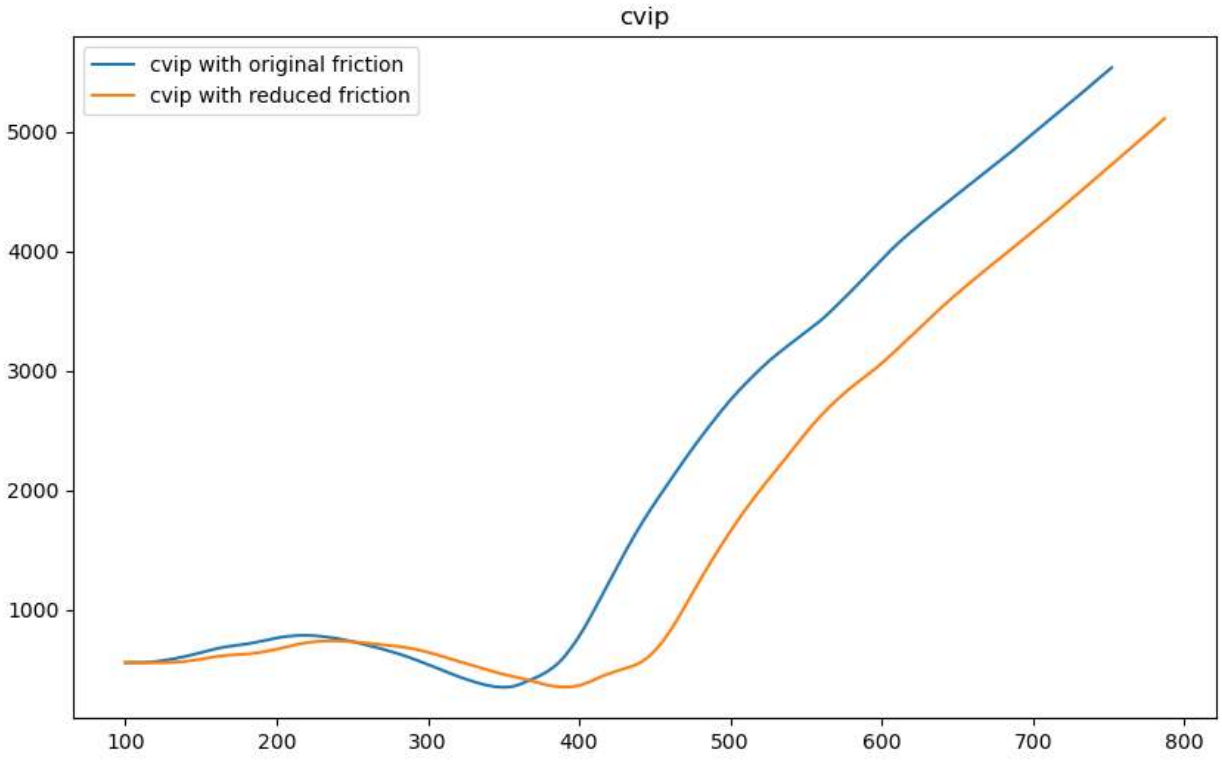
Since no accident, check cvip

In [14]:

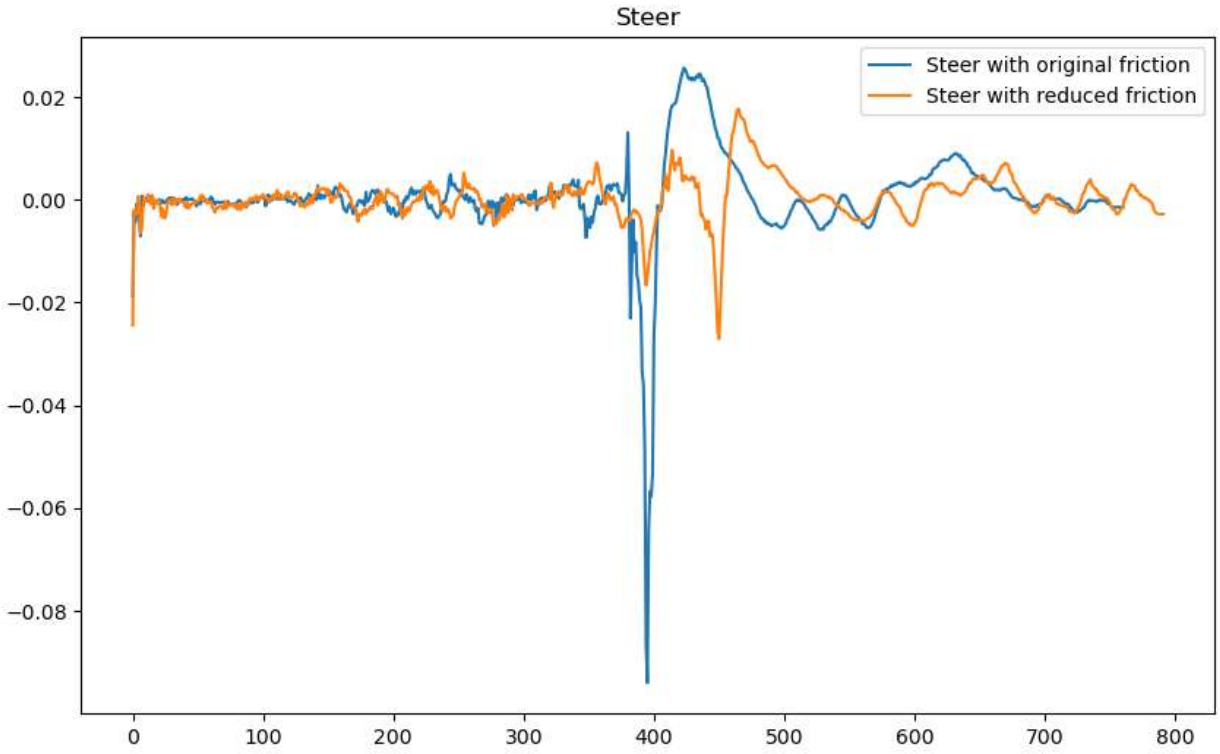
```
plt.figure(figsize=(10,6))

df_avg_orig_cvip = df_array_orig[0]['cvip']
count = 0

for i in range(1, len(df_array_orig)):
    if(df_array_orig[i]['cvip'].dtypes == 'object'):
        print(i)
    else:
        if not df_array_orig[i]['cvip'].isnull().values.any():
            df_avg_orig_cvip+=df_array_orig[i]['cvip']
            count+=1
df_avg_orig_cvip.interpolate().dropna()/count



df_avg_cvip = df_array[0]['cvip']

count = 0
for i in range(1, len(df_array)):
    if(df_array[i]['cvip'].dtypes == 'object'):
        print(i)
    else:
        if not df_array[i]['cvip'].isnull().values.any():
            df_avg_cvip+=df_array[i]['cvip']
            count+=1
df_avg_cvip.interpolate().dropna()/count
```

```
df_avg_orig_cvip.iloc[100:].plot(title="cvip")
df_avg_cvip.iloc[100:].plot()
plt.legend(["cvip with original friction", "cvip with reduced friction"])
```

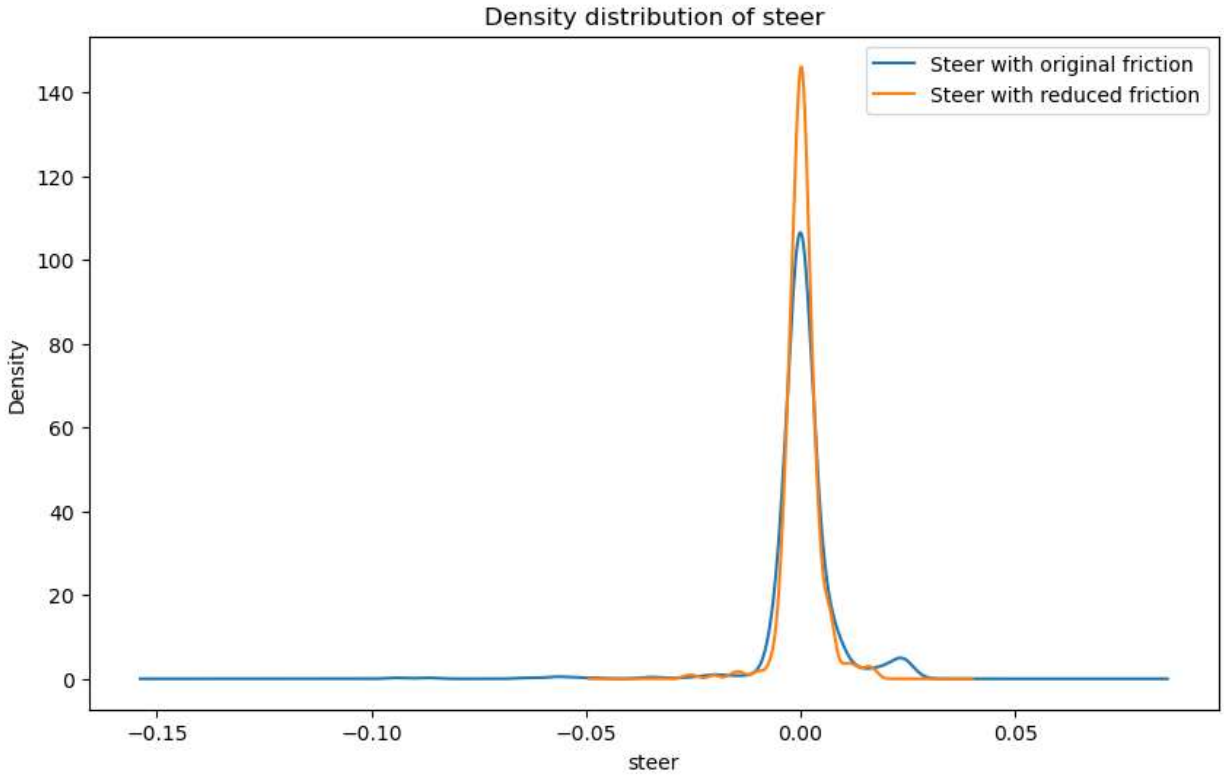
Out[14]: <matplotlib.legend.Legend at 0x14aff790fa0>



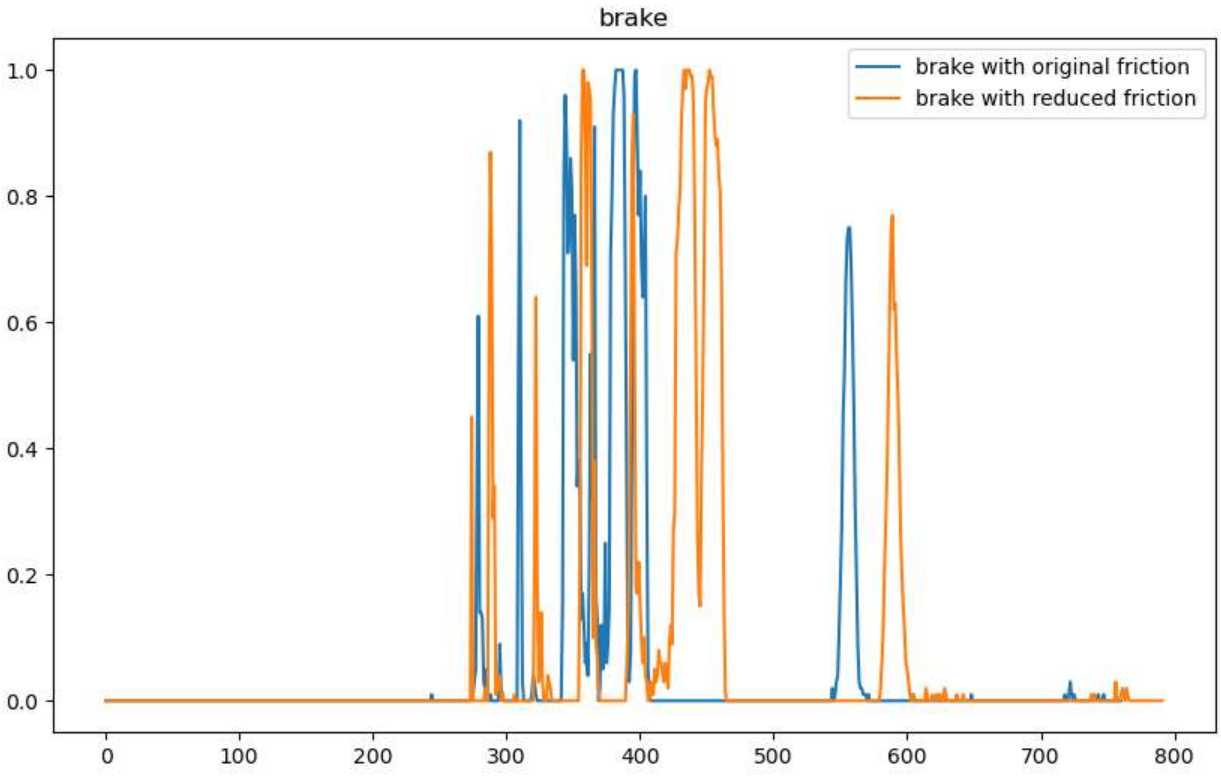
In [15]:
```
plt.figure(figsize=(10,6))

df_avg_orig = df_array_orig[0]['steer']
for i in range(1, len(df_array_orig)):
    df_avg_orig += df_array_orig[i]['steer']
df_avg_orig = df_avg_orig.interpolate().dropna()/100
df_avg_orig.plot()

df_avg = df_array[0]['steer']
for i in range(1, len(df_array)):
    df_avg += df_array[i]['steer']
df_avg = df_avg.interpolate().dropna()/100
df_avg.plot()


plt.title("Steer")
plt.legend(["Steer with original friction", "Steer with reduced friction"])
plt.show()
```



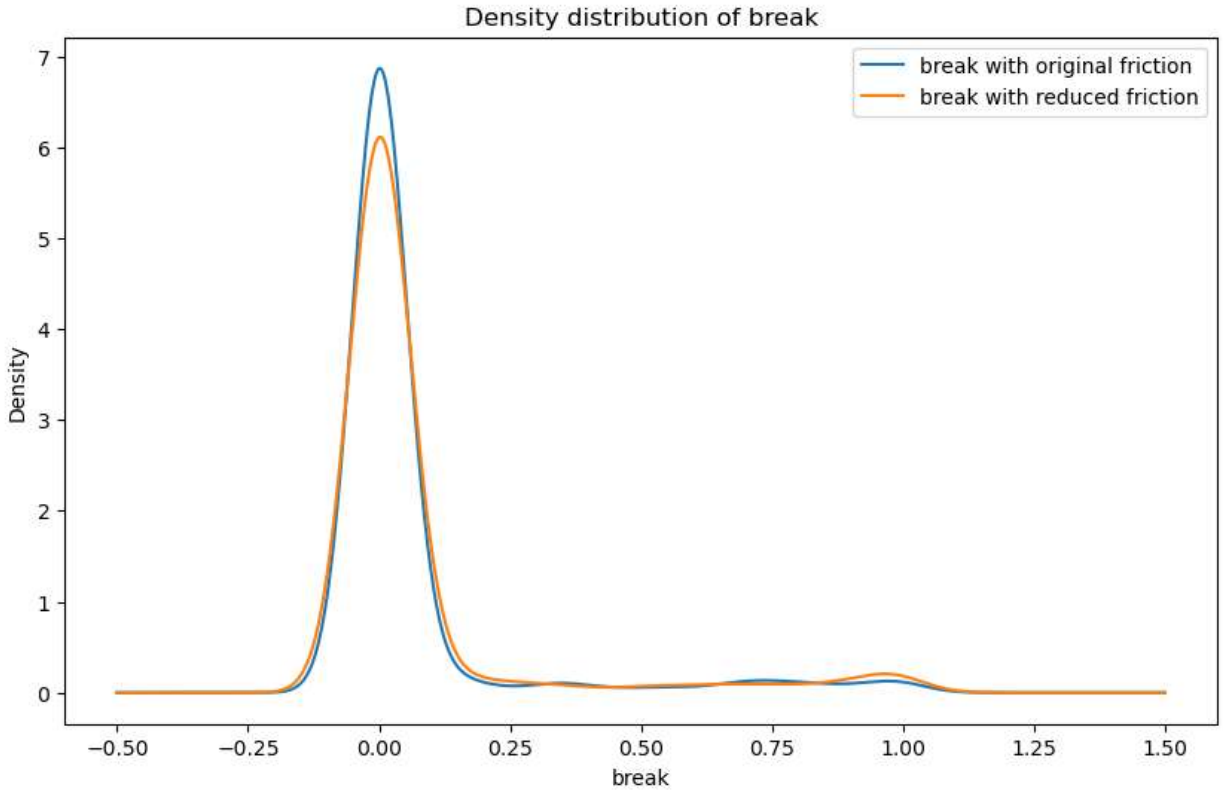
In [16]:
```
fig = plt.figure(figsize=(10, 6))


df_avg_orig.plot.density()
df_avg.plot.density()

plt.xlabel("steer")
plt.title('Density distribution of steer')

plt.legend(["Steer with original friction", "Steer with reduced friction"])

plt.show()
```



In [17]:
```
plt.figure(figsize=(10,6))

df_avg_orig = df_array_orig[0]['brake']
for i in range(1, len(df_array_orig)):
    df_avg_orig += df_array_orig[i]['brake']
df_avg_orig = df_avg_orig.interpolate().dropna()/100
df_avg_orig.plot()

df_avg = df_array[0]['brake']
for i in range(1, len(df_array)):
    df_avg += df_array[i]['brake']
df_avg = df_avg.interpolate().dropna()/100
df_avg.plot()


plt.title("brake")
plt.legend(["brake with original friction", "brake with reduced friction"])
plt.show()
```

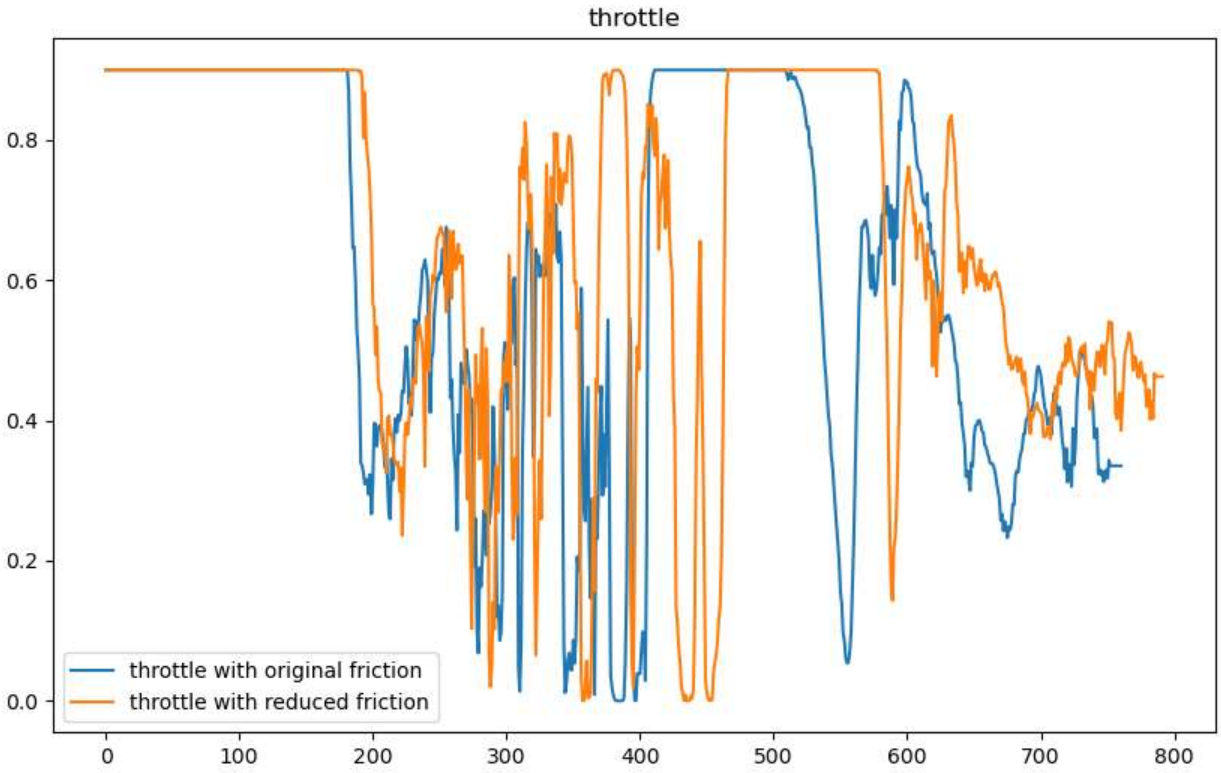


In [18]:
```
fig = plt.figure(figsize=(10, 6))


df_avg_orig.plot.density()
df_avg.plot.density()

plt.xlabel("break")
plt.title('Density distribution of break')

plt.legend(["break with original friction", "break with reduced friction"])

plt.show()
```

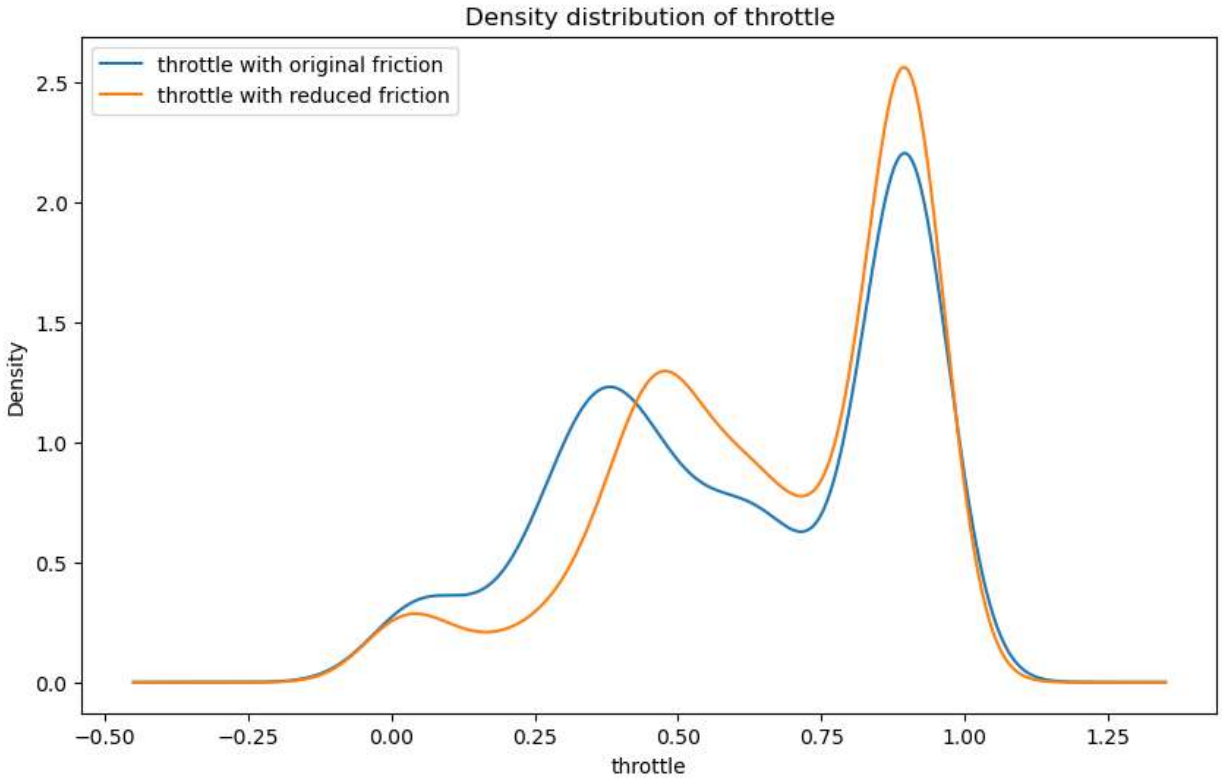


In [19]:

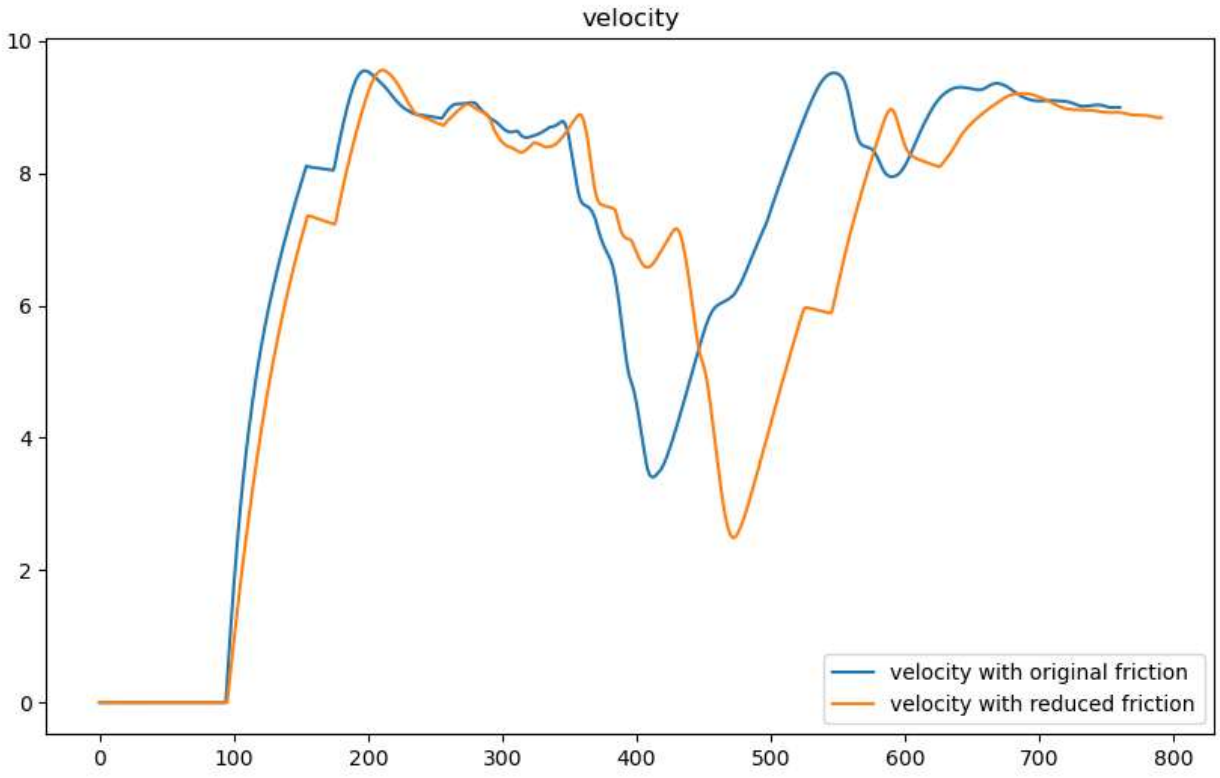
```
plt.figure(figsize=(10,6))

df_avg_orig = df_array_orig[0]['throttle']
for i in range(1, len(df_array_orig)):
    df_avg_orig += df_array_orig[i]['throttle']
df_avg_orig = df_avg_orig.interpolate().dropna()/100
df_avg_orig.plot()

df_avg = df_array[0]['throttle']
for i in range(1, len(df_array)):
    df_avg += df_array[i]['throttle']
df_avg = df_avg.interpolate().dropna()/100
df_avg.plot()


plt.title("throttle")
plt.legend(["throttle with original friction", "throttle with reduced friction"])
plt.show()
```



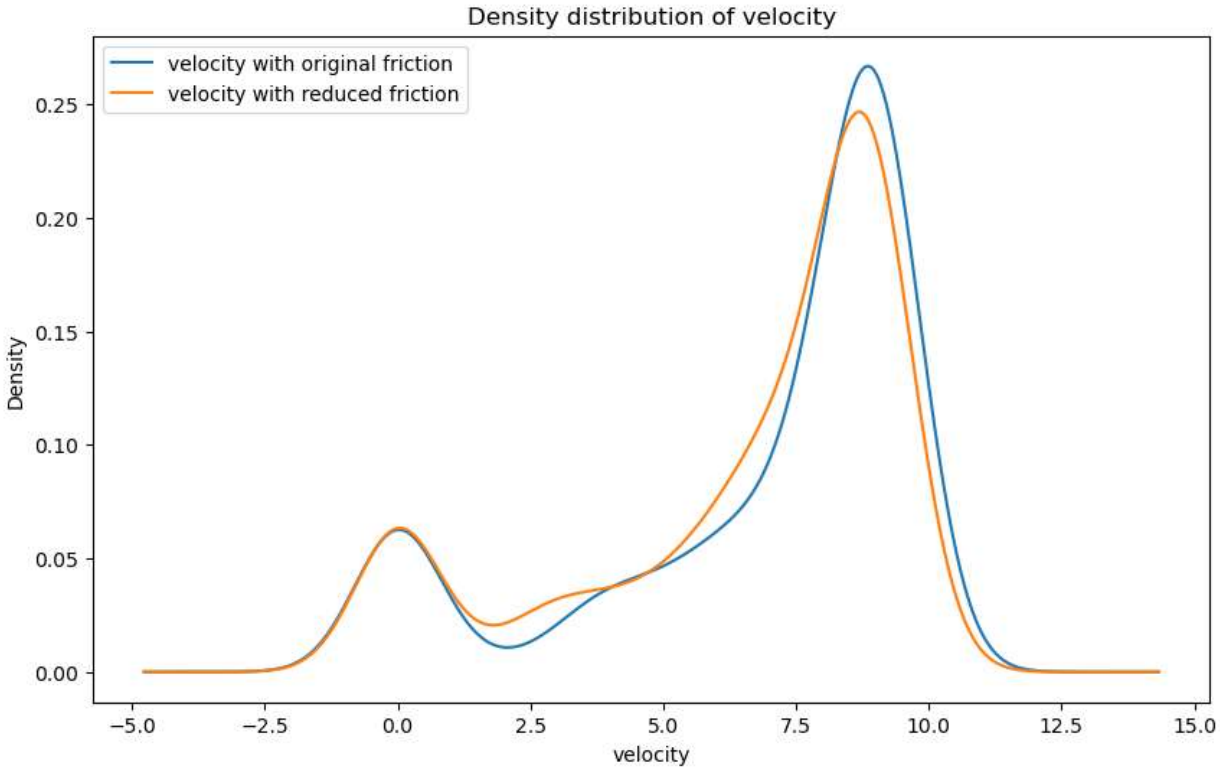
In [20]:
```
fig = plt.figure(figsize=(10, 6))


df_avg_orig.plot.density()
df_avg.plot.density()

plt.xlabel("throttle")
plt.title('Density distribution of throttle')

plt.legend(["throttle with original friction", "throttle with reduced friction"])

plt.show()
```



In [21]:
```
plt.figure(figsize=(10,6))

df_avg_orig = df_array_orig[0]['v']
for i in range(1, len(df_array_orig)):
    df_avg_orig += df_array_orig[i]['v']
df_avg_orig = df_avg_orig.interpolate().dropna()/100
df_avg_orig.plot()

df_avg = df_array[0]['v']
for i in range(1, len(df_array)):
    df_avg += df_array[i]['v']
df_avg = df_avg.interpolate().dropna()/100
df_avg.plot()


plt.title("velocity")
plt.legend(["velocity with original friction", "velocity with reduced friction"])
plt.show()
```



In [22]:
```
fig = plt.figure(figsize=(10, 6))


df_avg_orig.plot.density()
df_avg.plot.density()

plt.xlabel("velocity")
plt.title('Density distribution of velocity')

plt.legend(["velocity with original friction", "velocity with reduced friction"])

plt.show()
```



Dynamic time warping (DTW) for cvip

measuring similarity between two temporal sequences

In [23]:
```
distance = dtw.distance(df_avg_orig_cvip, df_avg_cvip)
```

In [24]:
```
distance
```

Out[24]:
```
nan
```

KS Test for cvip

In [25]:
```
import scipy as sp
```

In [26]:
```
sp.stats.ks_2samp(df_avg_orig_cvip, df_avg_cvip)
```

Out[26]:
```
KstestResult(statistic=0.12902845803634239, pvalue=4.2177381979173086e-06, statistic_
location=741.6077406786436, statistic_sign=-1)
```

You reject the null hypothesis that the two samples were drawn from the same distribution if the p-value is less than your significance level. **pvalue=4.2177381979173086e-06**