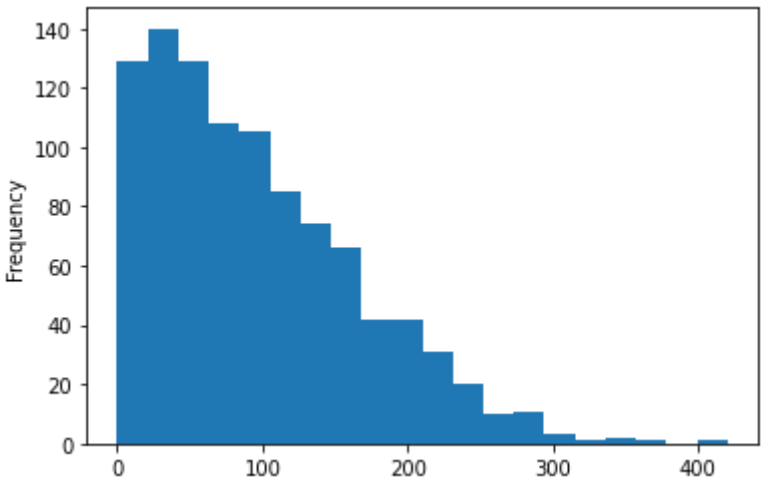
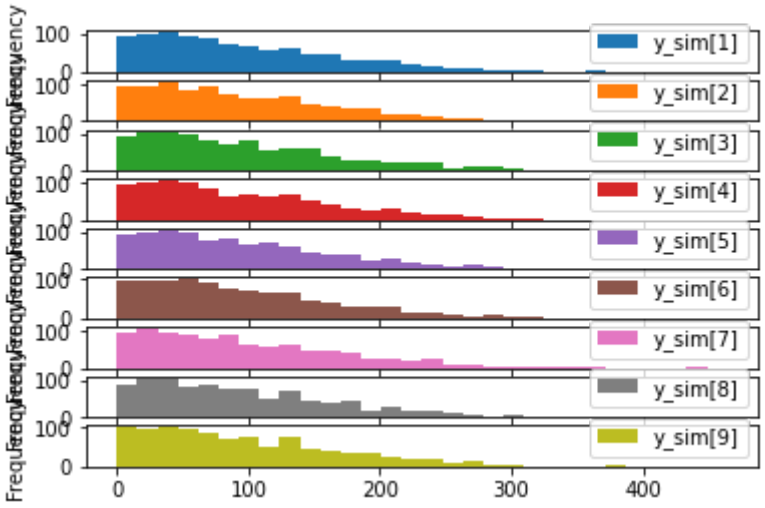
In [4]:
```
from cmdstanpy import CmdStanModel
import pandas as pd
import arviz as az
import numpy as np
import matplotlib.pyplot as plt
import scipy.stats as stats
import os

"""----------------------Exercise 1----------------------"""
#F=9, N=8
F = len('Katarzyna')
N = len('Wątorska')
L = len('Wątorska')

#1 complie stan model and sample it
#my_stan_file = os.path.join('.', 'code_1.stan')
my_stan_model = CmdStanModel(stan_file = '/home/kasia/Documents/DataAnaly
samples = my_stan_model.sample(data = {'M' : F}, fixed_param=True, iter_s

#2 dataframe
samples_dataframe = samples.draws_pd()

#3 histograms of y_sim and lambda
samples_lambda = samples_dataframe['lambda']
samples_lambda.plot.hist(bins = 20)
plt.show()

samples_dataframe2 = samples_dataframe.drop(samples_dataframe.columns[0:3
samples_dataframe2.plot.hist(subplots=True, bins=30)
plt.show()
```

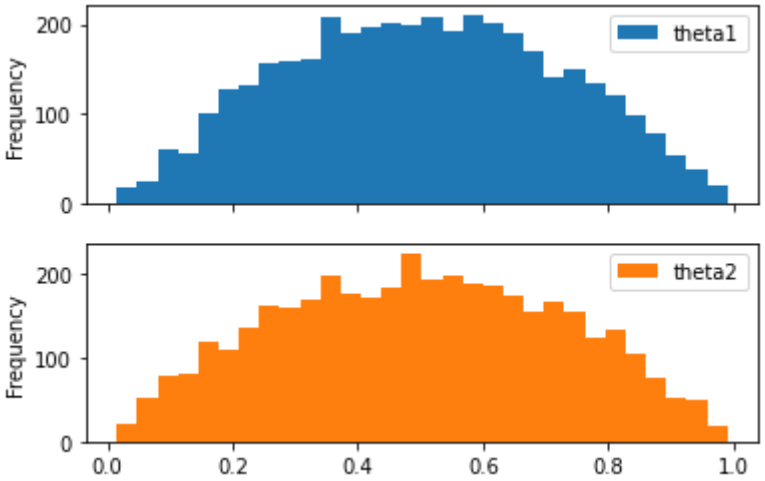
```
INFO:cmdstanpy:found newer exe file, not recompiling
INFO:cmdstanpy:CmdStan start processing
chain 1 |          | 00:00 Status

INFO:cmdstanpy:CmdStan done processing.
```





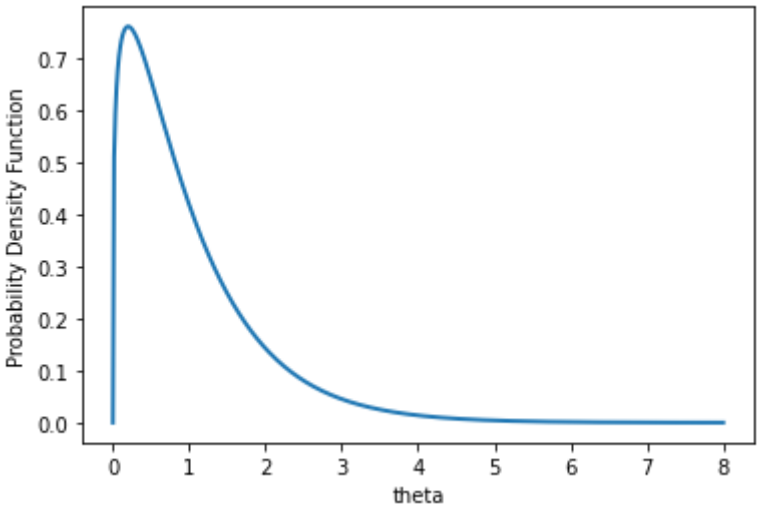
In [11]:
```
"""----------------------Exercise 2----------------------"""
bern1 = CmdStanModel(stan_file='code_2.stan')
samples_bern1 = bern1.sample(data={'N':2, 'y':[0,1]})
bern2 = CmdStanModel(stan_file='code_3.stan')
samples_bern2 = bern2.sample(data={'N':2, 'y':[0,1]})

theta1 = samples_bern1.stan_variable(var='theta')
theta2 = samples_bern2.stan_variable(var='theta')
df = pd.DataFrame({'theta1': theta1, 'theta2': theta2})
#df = pd.DataFrame({'theta2': theta2})
df.plot.hist(subplots=True, bins=30)
plt.show()
```

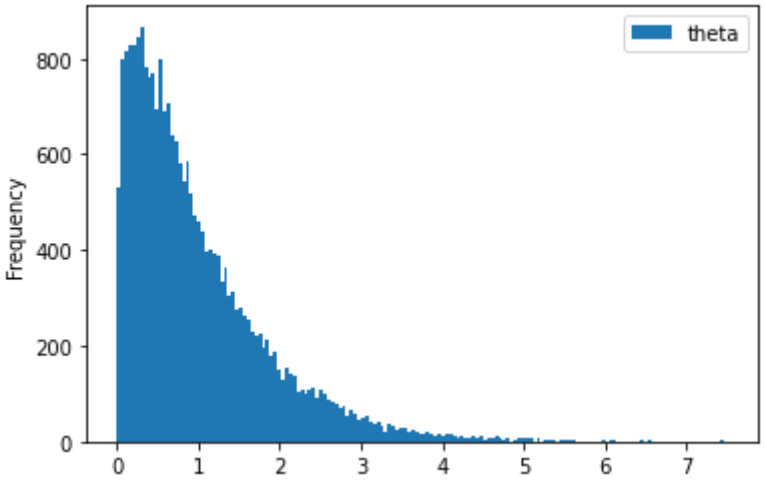
```
INFO:cmdstanpy:found newer exe file, not recompiling
INFO:cmdstanpy:CmdStan start processing
chain 1 |          | 00:00 Status
chain 2 |          | 00:00 Status
chain 3 |          | 00:00 Status
chain 4 |          | 00:00 Status

INFO:cmdstanpy:CmdStan done processing.

INFO:cmdstanpy:found newer exe file, not recompiling
INFO:cmdstanpy:CmdStan start processing
chain 1 |          | 00:00 Status
chain 2 |          | 00:00 Status
chain 3 |          | 00:00 Status
chain 4 |          | 00:00 Status

INFO:cmdstanpy:CmdStan done processing.
```



In [18]:
```
"""----------------------Exercise 3----------------------"""
#1 unconstrained parameteres
model_gm1 = CmdStanModel(stan_file='code_4.stan')
out_gamma1 = model_gm1.sample(output_dir='samples',iter_sampling=6000,ite
out_gamma1.diagnose()
N=500
xs = np.linspace(0,8,N)
pdfs = stats.gamma.pdf(xs, 1.25, scale = 1 / 1.25)

plt.plot(xs, pdfs, linewidth=2)

plt.gca().set_xlabel("theta")
plt.gca().set_ylabel("Probability Density Function")
plt.show()

theta_gm1 = out_gamma1.stan_variable(var='theta')
df_gm1 = pd.DataFrame({'theta': theta_gm1})
df_gm1.plot.hist(bins=160)
plt.show()
```

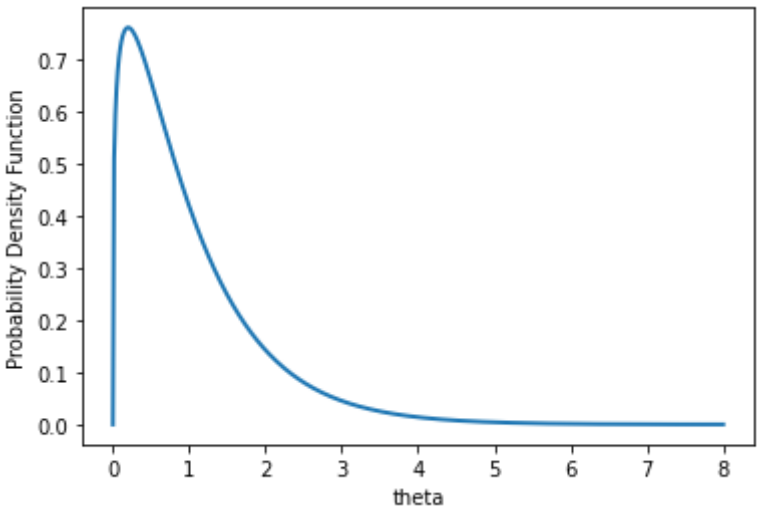
```
INFO:cmdstanpy:found newer exe file, not recompiling
INFO:cmdstanpy:CmdStan start processing
chain 1 |          | 00:00 Status
chain 2 |          | 00:00 Status
chain 3 |          | 00:00 Status
chain 4 |          | 00:00 Status

INFO:cmdstanpy:CmdStan done processing.
```

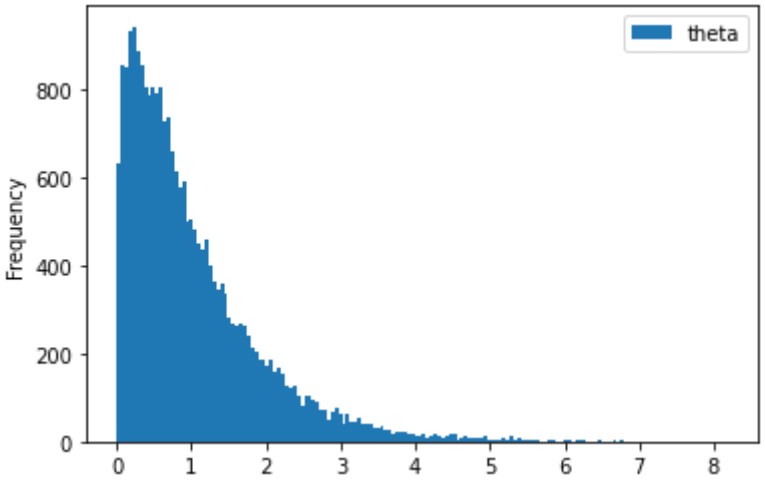




In [22]:
```
#2 constrained parameters
model_gm2 = CmdStanModel(stan_file='code_5.stan')
out_gamma2 = model_gm2.sample(output_dir='samples',iter_sampling=6000,ite
out_gamma2.diagnose()
N=500
xs = np.linspace(0,8,N)
pdfs = stats.gamma.pdf(xs, 1.25, scale = 1 / 1.25)

plt.plot(xs, pdfs, linewidth=2)
plt.gca().set_xlabel("theta")
plt.gca().set_ylabel("Probability Density Function")
plt.show()


theta_gm2 = out_gamma2.stan_variable(var='theta')
df_gm2 = pd.DataFrame({'theta': theta_gm2})
df_gm2.plot.hist(bins=160)
plt.show()
```

```
INFO:cmdstanpy:found newer exe file, not recompiling
INFO:cmdstanpy:CmdStan start processing
chain 1 |          | 00:00 Status
chain 2 |          | 00:00 Status
chain 3 |          | 00:00 Status
chain 4 |          | 00:00 Status

INFO:cmdstanpy:CmdStan done processing.
```





In [35]:
```
"""----------------------Exercise 4----------------------"""
model_tune = CmdStanModel(stan_file='/home/kasia/Documents/DataAnalytics/
F=9
L=8
y0 = 2# initial guess for the equation solving

data={'y_guess':[y0],
        'theta':[(F+L)/2]}
tunes = model_tune.sample(data=data, fixed_param=True, iter_sampling=1, i
tunes.draws_pd()
```

```
INFO:cmdstanpy:found newer exe file, not recompiling
INFO:cmdstanpy:CmdStan start processing
chain 1 |          | 00:00 Status

INFO:cmdstanpy:CmdStan done processing.
```

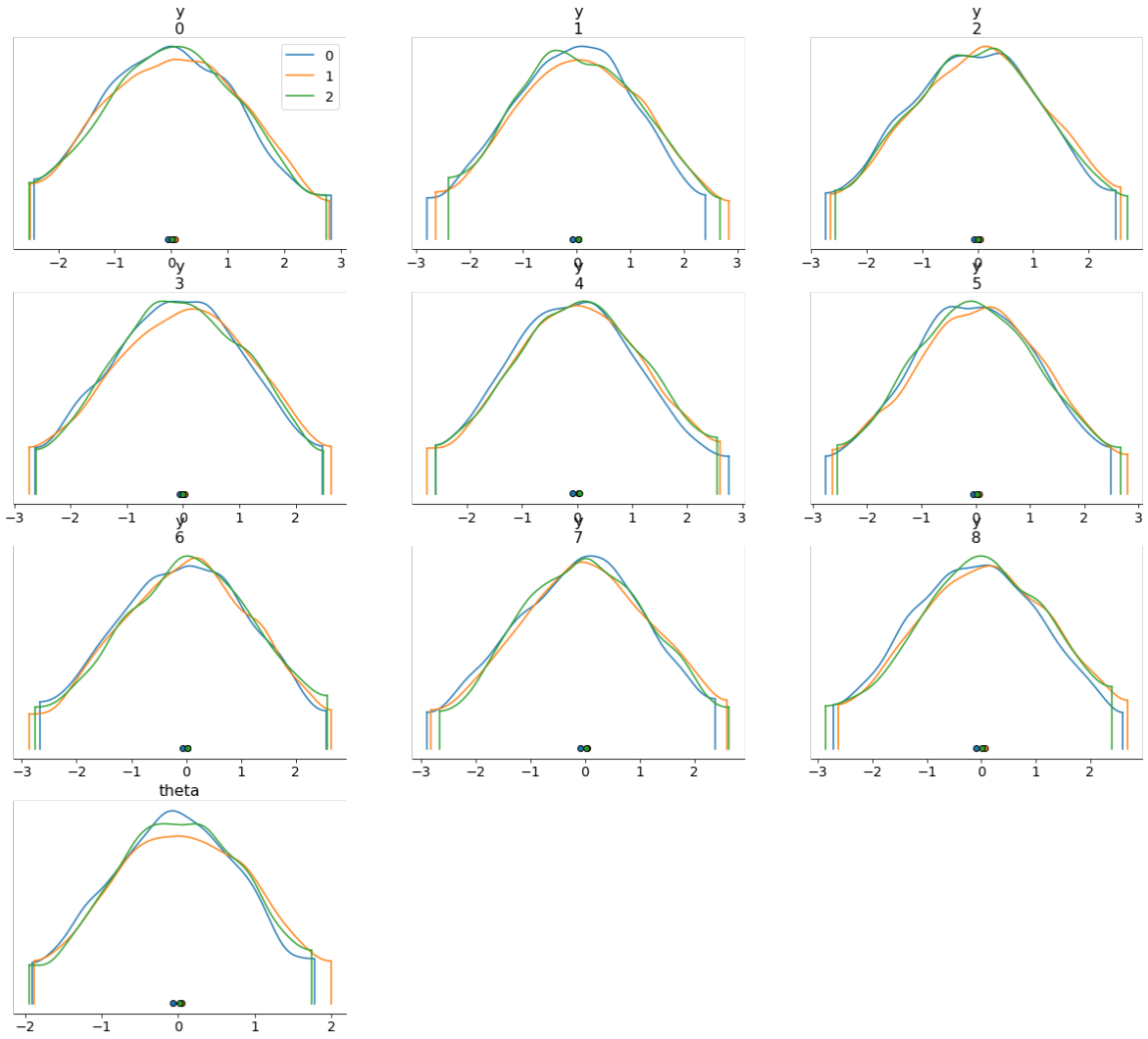
Out[35]:

	lp__	accept_stat__	sigma
0	0.0	0.0	3.29991

In [40]:
```
"""----------------------Exercise 5----------------------"""
model_samp_st = CmdStanModel(stan_file='code_7.stan')
model_log_target = CmdStanModel(stan_file='code_8.stan')
model_log_target_ind = CmdStanModel(stan_file='code_9.stan')
data = {'N': F}
seed = 5051998 #integer, your date of birth in the DDMMYYYY format withou
result_1 = model_samp_st.sample(data=data,seed=seed)
result_2 = model_log_target.sample(data=data,seed=seed)
result_3 = model_log_target_ind.sample(data=data,seed=seed)
az.plot_density([result_1,result_2,result_3])
plt.show()
```

```
INFO:cmdstanpy:found newer exe file, not recompiling
INFO:cmdstanpy:compiling stan file /home/kasia/Documents/DataAnalytics/La
b2/code_8.stan to exe file /home/kasia/Documents/DataAnalytics/Lab2/code_
8
INFO:cmdstanpy:compiled model executable: /home/kasia/Documents/DataAnaly
tics/Lab2/code_8
WARNING:cmdstanpy:Stan compiler has produced 1 warnings:
WARNING:cmdstanpy:
--- Translating Stan model to C++ code ---
bin/stanc  --o=/home/kasia/Documents/DataAnalytics/Lab2/code_8.hpp /home/
kasia/Documents/DataAnalytics/Lab2/code_8.stan
Warning in '/home/kasia/Documents/DataAnalytics/Lab2/code_8.stan', line
6, column 1: Declaration
    of arrays by placing brackets after a variable name is deprecated and
    will be removed in Stan 2.32.0. Instead use the array keyword before
the
    type. This can be changed automatically using the auto-format flag to
    stanc

--- Compiling, linking C++ code ---
g++ -std=c++1y -pthread -D_REENTRANT -Wno-sign-compare -Wno-ignored-attri
butes      -I stan/lib/stan_math/lib/tbb_2020.3/include    -O3 -I src -I
stan/src -I lib/rapidjson_1.1.0/ -I lib/CLI11-1.9.1/ -I stan/lib/stan_mat
h/ -I stan/lib/stan_math/lib/eigen_3.3.9 -I stan/lib/stan_math/lib/boost_
1.75.0 -I stan/lib/stan_math/lib/sundials_6.0.0/include -I stan/lib/stan_
math/lib/sundials_6.0.0/src/sundials    -DBOOST_DISABLE_ASSERTS
-c -Wno-ignored-attributes   -x c++ -o /home/kasia/Documents/DataAnalytic
s/Lab2/code_8.o /home/kasia/Documents/DataAnalytics/Lab2/code_8.hpp
g++ -std=c++1y -pthread -D_REENTRANT -Wno-sign-compare -Wno-ignored-attri
butes      -I stan/lib/stan_math/lib/tbb_2020.3/include    -O3 -I src -I
stan/src -I lib/rapidjson_1.1.0/ -I lib/CLI11-1.9.1/ -I stan/lib/stan_mat
h/ -I stan/lib/stan_math/lib/eigen_3.3.9 -I stan/lib/stan_math/lib/boost_
1.75.0 -I stan/lib/stan_math/lib/sundials_6.0.0/include -I stan/lib/stan_
math/lib/sundials_6.0.0/src/sundials    -DBOOST_DISABLE_ASSERTS
-Wl,-L,"/home/kasia/.cmdstan/cmdstan-2.29.1/stan/lib/stan_math/lib/tbb" -
Wl,-rpath,"/home/kasia/.cmdstan/cmdstan-2.29.1/stan/lib/stan_math/lib/tb
b"      /home/kasia/Documents/DataAnalytics/Lab2/code_8.o src/cmdstan/mai
n.o        -Wl,-L,"/home/kasia/.cmdstan/cmdstan-2.29.1/stan/lib/stan_math
/lib/tbb" -Wl,-rpath,"/home/kasia/.cmdstan/cmdstan-2.29.1/stan/lib/stan_m
ath/lib/tbb"   stan/lib/stan_math/lib/sundials_6.0.0/lib/libsundials_nvec
serial.a stan/lib/stan_math/lib/sundials_6.0.0/lib/libsundials_cvodes.a s
tan/lib/stan_math/lib/sundials_6.0.0/lib/libsundials_idas.a stan/lib/stan
_math/lib/sundials_6.0.0/lib/libsundials_kinsol.a  stan/lib/stan_math/lib
/tbb/libtbb.so.2 -o /home/kasia/Documents/DataAnalytics/Lab2/code_8
rm -f /home/kasia/Documents/DataAnalytics/Lab2/code_8.o

INFO:cmdstanpy:compiling stan file /home/kasia/Documents/DataAnalytics/La
b2/code_9.stan to exe file /home/kasia/Documents/DataAnalytics/Lab2/code_
9
INFO:cmdstanpy:compiled model executable: /home/kasia/Documents/DataAnaly
tics/Lab2/code_9
WARNING:cmdstanpy:Stan compiler has produced 1 warnings:
WARNING:cmdstanpy:
--- Translating Stan model to C++ code ---
bin/stanc  --o=/home/kasia/Documents/DataAnalytics/Lab2/code_9.hpp /home/
kasia/Documents/DataAnalytics/Lab2/code_9.stan
Warning in '/home/kasia/Documents/DataAnalytics/Lab2/code_9.stan', line
6, column 1: Declaration
    of arrays by placing brackets after a variable name is deprecated and
    will be removed in Stan 2.32.0. Instead use the array keyword before
the
    type. This can be changed automatically using the auto-format flag to
```

```
    stanc

--- Compiling, linking C++ code ---
g++ -std=c++1y -pthread -D_REENTRANT -Wno-sign-compare -Wno-ignored-attri
butes      -I stan/lib/stan_math/lib/tbb_2020.3/include    -O3 -I src -I
stan/src -I lib/rapidjson_1.1.0/ -I lib/CLI11-1.9.1/ -I stan/lib/stan_mat
h/ -I stan/lib/stan_math/lib/eigen_3.3.9 -I stan/lib/stan_math/lib/boost_
1.75.0 -I stan/lib/stan_math/lib/sundials_6.0.0/include -I stan/lib/stan_
math/lib/sundials_6.0.0/src/sundials    -DBOOST_DISABLE_ASSERTS
-c -Wno-ignored-attributes   -x c++ -o /home/kasia/Documents/DataAnalytic
s/Lab2/code_9.o /home/kasia/Documents/DataAnalytics/Lab2/code_9.hpp
g++ -std=c++1y -pthread -D_REENTRANT -Wno-sign-compare -Wno-ignored-attri
butes      -I stan/lib/stan_math/lib/tbb_2020.3/include    -O3 -I src -I
stan/src -I lib/rapidjson_1.1.0/ -I lib/CLI11-1.9.1/ -I stan/lib/stan_mat
h/ -I stan/lib/stan_math/lib/eigen_3.3.9 -I stan/lib/stan_math/lib/boost_
1.75.0 -I stan/lib/stan_math/lib/sundials_6.0.0/include -I stan/lib/stan_
math/lib/sundials_6.0.0/src/sundials    -DBOOST_DISABLE_ASSERTS
-Wl,-L,"/home/kasia/.cmdstan/cmdstan-2.29.1/stan/lib/stan_math/lib/tbb" -
Wl,-rpath,"/home/kasia/.cmdstan/cmdstan-2.29.1/stan/lib/stan_math/lib/tb
b"      /home/kasia/Documents/DataAnalytics/Lab2/code_9.o src/cmdstan/mai
n.o        -Wl,-L,"/home/kasia/.cmdstan/cmdstan-2.29.1/stan/lib/stan_math
/lib/tbb" -Wl,-rpath,"/home/kasia/.cmdstan/cmdstan-2.29.1/stan/lib/stan_m
ath/lib/tbb"   stan/lib/stan_math/lib/sundials_6.0.0/lib/libsundials_nvec
serial.a stan/lib/stan_math/lib/sundials_6.0.0/lib/libsundials_cvodes.a s
tan/lib/stan_math/lib/sundials_6.0.0/lib/libsundials_idas.a stan/lib/stan
_math/lib/sundials_6.0.0/lib/libsundials_kinsol.a  stan/lib/stan_math/lib
/tbb/libtbb.so.2 -o /home/kasia/Documents/DataAnalytics/Lab2/code_9
rm -f /home/kasia/Documents/DataAnalytics/Lab2/code_9.o

INFO:cmdstanpy:CmdStan start processing
chain 1 |          | 00:00 Status
chain 2 |          | 00:00 Status
chain 3 |          | 00:00 Status
chain 4 |          | 00:00 Status

INFO:cmdstanpy:CmdStan done processing.

INFO:cmdstanpy:CmdStan start processing
chain 1 |          | 00:00 Status
chain 2 |          | 00:00 Status
chain 3 |          | 00:00 Status
chain 4 |          | 00:00 Status

INFO:cmdstanpy:CmdStan done processing.

INFO:cmdstanpy:CmdStan start processing
chain 1 |          | 00:00 Status
chain 2 |          | 00:00 Status
chain 3 |          | 00:00 Status
chain 4 |          | 00:00 Status

INFO:cmdstanpy:CmdStan done processing.
```



In [58]:
```
"""----------------------Exercise 6----------------------"""
model_gq = CmdStanModel(stan_file='code_10.stan')
# fill in with chosen result from previous excercise
mean_of_y = model_gq.generate_quantities(data=data,
                                         mcmc_sample = result_1 )
print("mean: ", mean_of_y)
# investigate the output and plot histogram of mean_y variable
df = mean_of_y.draws()



theta_gq = mean_of_y.stan_variable(var='theta')
df_gq = pd.DataFrame({'theta': theta_gq})
df_gq.plot.hist(bins=160)
plt.show()
```

```
INFO:cmdstanpy:found newer exe file, not recompiling
INFO:cmdstanpy:Chain [1] start processing
INFO:cmdstanpy:Chain [1] done processing
INFO:cmdstanpy:Chain [2] start processing
INFO:cmdstanpy:Chain [2] done processing
INFO:cmdstanpy:Chain [3] start processing
INFO:cmdstanpy:Chain [3] done processing
INFO:cmdstanpy:Chain [4] start processing
INFO:cmdstanpy:Chain [4] done processing
```

```
mean:  CmdStanGQ: model=code_10 chains=4['method=generate_quantities', 'f
itted_params=/tmp/tmpfv7f0cto/code_7-20220320115141_1.csv']
 csv_files:
        /tmp/tmpfv7f0cto/code_10-20220320121359_1.csv
        /tmp/tmpfv7f0cto/code_10-20220320121359_2.csv
        /tmp/tmpfv7f0cto/code_10-20220320121359_3.csv
        /tmp/tmpfv7f0cto/code_10-20220320121359_4.csv
 output_files:
        /tmp/tmpfv7f0cto/code_10-20220320121359_0-stdout.txt
        /tmp/tmpfv7f0cto/code_10-20220320121359_1-stdout.txt
        /tmp/tmpfv7f0cto/code_10-20220320121359_2-stdout.txt
        /tmp/tmpfv7f0cto/code_10-20220320121359_3-stdout.txt
```