INDIA_DILIP_COVID19_LD0

Part 1:

```
# PYTHON CODE FOR "SIR" MODEL OF INDIA ///LOCKDOWN-0 (FROM 22TH FEB 2020 TO 24TH MARCH 2020)

import numpy as np

import pandas as pd

import matplotlib.pyplot as plt

import matplotlib


# INDIA ///LOCKDOWN-0 (FROM 22TH FEB 2020 TO 24TH MARCH 2020)

#DATASET FROM JHU-CSSE: https://github.com/CSSEGISandData/COVID-19/tree/master/csse_covid_19_data/csse_covid_19_time_series

#FOR TOTAL CONFIRMED CASES: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_confirmed_global.csv

#FOR DEATHS: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_deaths_global.csv

#FOR RECOVERED: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_recovered_global.csv


Total_confirmed_cases_of_India=[0,0,0,0,0,0,0,0,1,1,1,2,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,
3,3,3,5,5,28,30,31,34,39,43,56,62,73,82,102,113,119,142,156,194,244,330,396,499,536]

Death_cases_of_India=[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,1,1,2,2,2,2,3,3,4,5,4,7,10,10]

Recovered_cases_of_India=[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3
,3,3,3,3,3,3,3,4,4,4,4,4,13,13,14,14,15,20,23,27,27,40]


R=[x + y for x, y in zip(Death_cases_of_India, Recovered_cases_of_India)]

I=[x - y for x, y in zip(Total_confirmed_cases_of_India, R)]


plt.figure();

plt.plot(Total_confirmed_cases_of_India, 'o-k');
```

```
plt.plot(Death_cases_of_India, 'o-r');
plt.plot(Recovered_cases_of_India, 'o-g');
plt.legend(['Total_confirmed_cases_of_India', 'Death_cases_of_India', 'Recovered_cases_of_India'])
plt.grid(1);
plt.yscale('log')
plt.xlabel('LOCKDOWN-0 (FROM 22TH FEB 2020 TO 24TH MARCH 2020)')
plt.figure();

en=len(Total_confirmed_cases_of_India); st=en-7;
y=np.log(I[st:en])
t=np.array(range(st, en))
m, b = np.polyfit(t, y, 1)
plt.plot(t, (y), 'o')
plt.plot(t, (m*t + b))
plt.title('m estimate: %s' % m)
plt.grid()
plt.figure()
g=[]
for i in range(st, en-1):
   oo=(R[i+1]-R[i])/I[i]
   g.append(oo)
plt.plot(g)
plt.grid(1)
gamma= np.mean(g);
plt.title('gamma estimate: %s' % gamma)
gamma
beta=m+gamma
print('gamma=%g beta=%g R0=%g' %(gamma, beta, beta/gamma))
```

Part 2:

```
def INDIA_SIR_COVID19_MODEL(S0,I0,R0,t0, t1, beta, gamma):
    N=S0+R0+I0;
    S=S0; R=R0; I=I0;
    SS=[S0];RR=[R0]; II=[I0];
    tt=[t0];
    dt=0.1;
    t=t0
    while t <= t1:
        dS=-beta*S*I/N
        dI=beta*S*I/N-gamma*I
        dR=gamma*I
        S=S+dt*dS;
        I=I+dt*dI;
        R=R+dt*dR;
        SS.append(S); II.append(I); RR.append(R)
        t=t+dt;
        tt.append(t)
    return(SS,II,RR,tt)


SIR=INDIA_SIR_COVID19_MODEL(1380004385, I[en-1], R[en-1], 0, 500, beta, gamma)
tt=SIR[3]; SS=SIR[0]; II=SIR[1]; RR=SIR[2];
plt.plot(tt, SS, '--r')
plt.plot(tt, II, '--g')
plt.plot(tt, RR, '--b')
plt.grid(1)
plt.legend(['S=Susceptible','I=Infected','R=Recovered'])
oo=II.index(max(II));
N=(II[0]+RR[0]+SS[0]);
```

```
tmax=tt[oo]; Imax=II[oo];

inftot = RR[-1]/N

plt.xlabel('Number of Days')

plt.ylabel('Population of India')

plt.title('t_max= %g, I_max= %2.3g%%, S_inf: %2.4g%%'  % (tmax, Imax/N*100, inftot*100))
```

INDIA_DILIP_COVID19_LD1

Part 1:

```
# PYTHON CODE FOR "SIR" MODEL OF INDIA ///LOCKDOWN-1 (FROM 25TH MARCH 2020 TO 14TH APRIL 2020)

import numpy as np

import pandas as pd

import matplotlib.pyplot as plt

import matplotlib


# INDIA ///LOCKDOWN-1 (FROM 25TH MARCH 2020 TO 14TH APRIL 2020)

#DATASET FROM JHU-CSSE: https://github.com/CSSEGISandData/COVID-19/tree/master/csse_covid_19_data/csse_covid_19_time_series

#FOR TOTAL CONFIRMED CASES: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_confirmed_global.csv

#FOR DEATHS: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_deaths_global.csv

#FOR RECOVERED: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_recovered_global.csv


Total_confirmed_cases_of_India=[657,727,887,987,1024,1251,1397,1998,2543,2567,3082,3588,4778,5311,5916,6725,7598,8446,9205,10453,11487]

Death_cases_of_India=[12,20,20,24,27,32,35,58,72,72,86,99,136,150,178,226,246,288,331,358,393]

Recovered_cases_of_India=[43,45,73,84,95,102,123,148,191,192,229,229,375,421,506,620,774,969,1080,1181,1359]


R=[x + y for x, y in zip(Death_cases_of_India, Recovered_cases_of_India)]

I=[x - y for x, y in zip(Total_confirmed_cases_of_India, R)]


plt.figure();

plt.plot(Total_confirmed_cases_of_India, 'o-k');

plt.plot(Death_cases_of_India, 'o-r');
```

```
plt.plot(Recovered_cases_of_India, 'o-g');
plt.legend(['Total_confirmed_cases_of_India', 'Death_cases_of_India', 'Recovered_cases_of_India'])
plt.grid(1);
plt.yscale('log')
plt.xlabel('LOCKDOWN-1 (FROM 25TH MARCH 2020 TO 14TH APRIL 2020)')
plt.figure();

en=len(Total_confirmed_cases_of_India); st=en-7;
y=np.log(I[st:en])
t=np.array(range(st, en))
m, b = np.polyfit(t, y, 1)
plt.plot(t, (y), 'o')
plt.plot(t, (m*t + b))
plt.title('m estimate: %s' % m)
plt.grid()
plt.figure()
g=[]
for i in range(st, en-1):
   oo=(R[i+1]-R[i])/I[i]
   g.append(oo)
plt.plot(g)
plt.grid(1)
gamma= np.mean(g);
plt.title('gamma estimate: %s' % gamma)
gamma
beta=m+gamma
print('gamma=%g beta=%g R0=%g' %(gamma, beta, beta/gamma))
```

Part 2:

```
def INDIA_SIR_COVID19_MODEL(S0,I0,R0,t0, t1, beta, gamma):
    N=S0+R0+I0;
    S=S0; R=R0; I=I0;
    SS=[S0];RR=[R0]; II=[I0];
    tt=[t0];
    dt=0.1;
    t=t0
    while t <= t1:
        dS=-beta*S*I/N
        dI=beta*S*I/N-gamma*I
        dR=gamma*I
        S=S+dt*dS;
        I=I+dt*dI;
        R=R+dt*dR;
        SS.append(S); II.append(I); RR.append(R)
        t=t+dt;
        tt.append(t)
    return(SS,II,RR,tt)


SIR=INDIA_SIR_COVID19_MODEL(1380003673, I[en-1], R[en-1], 0, 500, beta, gamma)
tt=SIR[3]; SS=SIR[0]; II=SIR[1]; RR=SIR[2];
plt.plot(tt, SS, '--r')
plt.plot(tt, II, '--g')
plt.plot(tt, RR, '--b')
plt.grid(1)
plt.legend(['S=Susceptible','I=Infected','R=Recovered'])
oo=II.index(max(II));
N=(II[0]+RR[0]+SS[0]);
```

```
tmax=tt[oo]; Imax=II[oo];

inftot = RR[-1]/N

plt.xlabel('Number of Days')

plt.ylabel('Population of India')

plt.title('t_max= %g, I_max= %2.3g%%, S_inf: %2.4g%%'  % (tmax, Imax/N*100, inftot*100))
```

INDIA_DILIP_COVID19_LD2

Part 1:

```
# PYTHON CODE FOR "SIR" MODEL OF INDIA ///LOCKDOWN-2 (FROM 15TH APRIL 2020 TO 3RD MAY 2020)

import numpy as np

import pandas as pd

import matplotlib.pyplot as plt

import matplotlib


# INDIA ///LOCKDOWN-2 (FROM 15TH APRIL 2020 TO 3RD MAY 2020)

#DATASET FROM JHU-CSSE: https://github.com/CSSEGISandData/COVID-19/tree/master/csse_covid_19_data/csse_covid_19_time_series

#FOR TOTAL CONFIRMED CASES: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_confirmed_global.csv

#FOR DEATHS: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_deaths_global.csv

#FOR RECOVERED: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_recovered_global.csv


Total_confirmed_cases_of_India=[12322,13430,14352,15722,17615,18539,20080,21370,23077,24530,26283,27890,29451,31324,33062,34863,37257,39699,42505]

Death_cases_of_India=[405,448,486,521,559,592,645,681,721,780,825,881,939,1008,1079,1154,1223,1323,1391]

Recovered_cases_of_India=[1432,1768,2041,2463,2854,3273,3975,4370,5012,5498,5939,6523,7137,7747,8437,9068,10007,10819,11775]


R=[x + y for x, y in zip(Death_cases_of_India, Recovered_cases_of_India)]

I=[x - y for x, y in zip(Total_confirmed_cases_of_India, R)]


plt.figure();

plt.plot(Total_confirmed_cases_of_India, 'o-k');
```

```
plt.plot(Death_cases_of_India, 'o-r');
plt.plot(Recovered_cases_of_India, 'o-g');
plt.legend(['Total_confirmed_cases_of_India', 'Death_cases_of_India', 'Recovered_cases_of_India'])
plt.grid(1);
plt.yscale('log')
plt.xlabel('LOCKDOWN-2 (FROM 15TH APRIL 2020 TO 3RD MAY 2020)')
plt.figure();

en=len(Total_confirmed_cases_of_India); st=en-7;
y=np.log(I[st:en])
t=np.array(range(st, en))
m, b = np.polyfit(t, y, 1)
plt.plot(t, (y), 'o')
plt.plot(t, (m*t + b))
plt.title('m estimate: %s' % m)
plt.grid()
plt.figure()
g=[]
for i in range(st, en-1):
   oo=(R[i+1]-R[i])/I[i]
   g.append(oo)
plt.plot(g)
plt.grid(1)
gamma= np.mean(g);
plt.title('gamma estimate: %s' % gamma)
gamma
beta=m+gamma
print('gamma=%g beta=%g R0=%g' %(gamma, beta, beta/gamma))
```

Part 2:

```
def INDIA_SIR_COVID19_MODEL(S0,I0,R0,t0, t1, beta, gamma):
    N=S0+R0+I0;
    S=S0; R=R0; I=I0;
    SS=[S0];RR=[R0]; II=[I0];
    tt=[t0];
    dt=0.1;
    t=t0
    while t <= t1:
        dS=-beta*S*I/N
        dI=beta*S*I/N-gamma*I
        dR=gamma*I
        S=S+dt*dS;
        I=I+dt*dI;
        R=R+dt*dR;
        SS.append(S); II.append(I); RR.append(R)
        t=t+dt;
        tt.append(t)
    return(SS,II,RR,tt)


SIR=INDIA_SIR_COVID19_MODEL(1379990226, I[en-1], R[en-1], 0, 500, beta, gamma)
tt=SIR[3]; SS=SIR[0]; II=SIR[1]; RR=SIR[2];
plt.plot(tt, SS, '--r')
plt.plot(tt, II, '--g')
plt.plot(tt, RR, '--b')
plt.grid(1)
plt.legend(['S=Susceptible','I=Infected','R=Recovered'])
oo=II.index(max(II));
N=(II[0]+RR[0]+SS[0]);
```

```
tmax=tt[oo]; Imax=II[oo];

inftot = RR[-1]/N

plt.xlabel('Number of Days')

plt.ylabel('Population of India')

plt.title('t_max= %g, I_max= %2.3g%%, S_inf: %2.4g%%'  % (tmax, Imax/N*100, inftot*100))
```

INDIA_DILIP_COVID19_LD3

Part 1:

```
# PYTHON CODE FOR "SIR" MODEL OF INDIA ///LOCKDOWN-3 (FROM 4TH MAY 2020 TO 17TH MAY 2020)

import numpy as np

import pandas as pd

import matplotlib.pyplot as plt

import matplotlib


# INDIA ///LOCKDOWN-3 (FROM 4TH MAY 2020 TO 17TH MAY 2020)

#DATASET FROM JHU-CSSE: https://github.com/CSSEGISandData/COVID-19/tree/master/csse_covid_19_data/csse_covid_19_time_series

#FOR TOTAL CONFIRMED CASES: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_confirmed_global.csv

#FOR DEATHS: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_deaths_global.csv

#FOR RECOVERED: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_recovered_global.csv


Total_confirmed_cases_of_India=[46437,49400,52987,56351,59695,62808,67161,70768,74292,78055,81997,85784,90648,95698]

Death_cases_of_India=[1566,1693,1785,1889,1985,2101,2212,2294,2415,2551,2649,2753,2871,3025]

Recovered_cases_of_India=[12847,14142,15331,16776,17887,19301,20969,22549,24420,26400,27969,30258,34224,36795]


R=[x + y for x, y in zip(Death_cases_of_India, Recovered_cases_of_India)]

I=[x - y for x, y in zip(Total_confirmed_cases_of_India, R)]


plt.figure();

plt.plot(Total_confirmed_cases_of_India, 'o-k');

plt.plot(Death_cases_of_India, 'o-r');
```

```
plt.plot(Recovered_cases_of_India, 'o-g');
plt.legend(['Total_confirmed_cases_of_India', 'Death_cases_of_India', 'Recovered_cases_of_India'])
plt.grid(1);
plt.yscale('log')
plt.xlabel('LOCKDOWN-3 (FROM 4TH MAY 2020 TO 17TH MAY 2020)')
plt.figure();

en=len(Total_confirmed_cases_of_India); st=en-7;
y=np.log(I[st:en])
t=np.array(range(st, en))
m, b = np.polyfit(t, y, 1)
plt.plot(t, (y), 'o')
plt.plot(t, (m*t + b))
plt.title('m estimate: %s' % m)
plt.grid()
plt.figure()
g=[]
for i in range(st, en-1):
   oo=(R[i+1]-R[i])/I[i]
   g.append(oo)
plt.plot(g)
plt.grid(1)
gamma= np.mean(g);
plt.title('gamma estimate: %s' % gamma)
gamma
beta=m+gamma
print('gamma=%g beta=%g R0=%g' %(gamma, beta, beta/gamma))
```

Part 2:

```
def INDIA_SIR_COVID19_MODEL(S0,I0,R0,t0, t1, beta, gamma):
    N=S0+R0+I0;
    S=S0; R=R0; I=I0;
    SS=[S0];RR=[R0]; II=[I0];
    tt=[t0];
    dt=0.1;
    t=t0
    while t <= t1:
        dS=-beta*S*I/N
        dI=beta*S*I/N-gamma*I
        dR=gamma*I
        S=S+dt*dS;
        I=I+dt*dI;
        R=R+dt*dR;
        SS.append(S); II.append(I); RR.append(R)
        t=t+dt;
        tt.append(t)
    return(SS,II,RR,tt)


SIR=INDIA_SIR_COVID19_MODEL(1379943535, I[en-1], R[en-1], 0, 500, beta, gamma)
tt=SIR[3]; SS=SIR[0]; II=SIR[1]; RR=SIR[2];
plt.plot(tt, SS, '--r')
plt.plot(tt, II, '--g')
plt.plot(tt, RR, '--b')
plt.grid(1)
plt.legend(['S=Susceptible','I=Infected','R=Recovered'])
oo=II.index(max(II));
N=(II[0]+RR[0]+SS[0]);
```

```
tmax=tt[oo]; Imax=II[oo];

inftot = RR[-1]/N

plt.xlabel('Number of Days')

plt.ylabel('Population of India')

plt.title('t_max= %g, I_max= %2.3g%%, S_inf: %2.4g%%'  % (tmax, Imax/N*100, inftot*100))
```

INDIA_DILIP_COVID19_LD4

Part 1:

```
# PYTHON CODE FOR "SIR" MODEL OF INDIA ///LOCKDOWN 4 (18TH MAY 2020 TO 31ST MAY 2020)

import numpy as np

import pandas as pd

import matplotlib.pyplot as plt

import matplotlib


# INDIA ///LOCKDOWN 4 (18TH MAY 2020 TO 31ST MAY 2020)

#DATASET FROM JHU-CSSE: https://github.com/CSSEGISandData/COVID-19/tree/master/csse_covid_19_data/csse_covid_19_time_series

#FOR TOTAL CONFIRMED CASES: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_confirmed_global.csv

#FOR DEATHS: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_deaths_global.csv

#FOR RECOVERED: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_recovered_global.csv


Total_confirmed_cases_of_India=[100328,106475,112028,118226,124794,131423,138536,144950,150793,158086,165386,173491,181827,190609]

Death_cases_of_India=[3156,3302,3434,3584,3726,3868,4024,4172,4344,4534,4711,4980,5185,5408]

Recovered_cases_of_India=[39233,42309,45422,48553,51824,54385,57692,60706,64277,67749,70920,82627,86936,91852]


R=[x + y for x, y in zip(Death_cases_of_India, Recovered_cases_of_India)]

I=[x - y for x, y in zip(Total_confirmed_cases_of_India, R)]


plt.figure();

plt.plot(Total_confirmed_cases_of_India, 'o-k');

plt.plot(Death_cases_of_India, 'o-r');
```

```
plt.plot(Recovered_cases_of_India, 'o-g');
plt.legend(['Total_confirmed_cases_of_India', 'Death_cases_of_India', 'Recovered_cases_of_India'])
plt.grid(1);
plt.yscale('log')
plt.xlabel('LOCKDOWN 4 (18TH MAY 2020 TO 31ST MAY 2020)')
plt.figure();

en=len(Total_confirmed_cases_of_India); st=en-7;
y=np.log(I[st:en])
t=np.array(range(st, en))
m, b = np.polyfit(t, y, 1)
plt.plot(t, (y), 'o')
plt.plot(t, (m*t + b))
plt.title('m estimate: %s' % m)
plt.grid()
plt.figure()
g=[]
for i in range(st, en-1):
   oo=(R[i+1]-R[i])/I[i]
   g.append(oo)
plt.plot(g)
plt.grid(1)
gamma= np.mean(g);
plt.title('gamma estimate: %s' % gamma)
gamma
beta=m+gamma
print('gamma=%g beta=%g R0=%g' %(gamma, beta, beta/gamma))
```

Part 2:

```
def INDIA_SIR_COVID19_MODEL(S0,I0,R0,t0, t1, beta, gamma):
    N=S0+R0+I0;
    S=S0; R=R0; I=I0;
    SS=[S0];RR=[R0]; II=[I0];
    tt=[t0];
    dt=0.1;
    t=t0
    while t <= t1:
        dS=-beta*S*I/N
        dI=beta*S*I/N-gamma*I
        dR=gamma*I
        S=S+dt*dS;
        I=I+dt*dI;
        R=R+dt*dR;
        SS.append(S); II.append(I); RR.append(R)
        t=t+dt;
        tt.append(t)
    return(SS,II,RR,tt)


SIR=INDIA_SIR_COVID19_MODEL(1379861668, I[en-1], R[en-1], 0, 500, beta, gamma)
tt=SIR[3]; SS=SIR[0]; II=SIR[1]; RR=SIR[2];
plt.plot(tt, SS, '--r')
plt.plot(tt, II, '--g')
plt.plot(tt, RR, '--b')
plt.grid(1)
plt.legend(['S=Susceptible','I=Infected','R=Recovered'])
oo=II.index(max(II));
N=(II[0]+RR[0]+SS[0]);
```

```
tmax=tt[oo]; Imax=II[oo];

inftot = RR[-1]/N

plt.xlabel('Number of Days')

plt.ylabel('Population of India')

plt.title('t_max= %g, I_max= %2.3g%%, S_inf: %2.4g%%'  % (tmax, Imax/N*100, inftot*100))
```

INDIA_DILIP_COVID19_LD_0-4

Part 1:

```
# PYTHON CODE FOR "SIR" MODEL OF INDIA ///LOCKDOWN 0-4 (22ND FEB 2020 TO 31ST MAY 2020)

import numpy as np

import pandas as pd

import matplotlib.pyplot as plt

import matplotlib


# INDIA ///LOCKDOWN 0-4 (22ND FEB 2020 TO 31ST MAY 2020)

#DATASET FROM JHU-CSSE: https://github.com/CSSEGISandData/COVID-19/tree/master/csse_covid_19_data/csse_covid_19_time_series

#FOR TOTAL CONFIRMED CASES: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_confirmed_global.csv

#FOR DEATHS: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_deaths_global.csv

#FOR RECOVERED: https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_recovered_global.csv


Total_confirmed_cases_of_India=[0,0,0,0,0,0,0,1,1,1,2,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,5,5,28,30,31,34,39,43,56,62,73,82,102,113,119,142,156,194,244,330,396,499,536,657,727,887,987,1024,1251,1397,1998,2543,2567,3082,3588,4778,5311,5916,6725,7598,8446,9205,10453,11487,12322,13430,14352,15722,17615,18539,20080,21370,23077,24530,26283,27890,29451,31324,33062,34863,37257,39699,42505,46437,49400,52987,56351,59695,62808,67161,70768,74292,78055,81997,85784,90648,95698,100328,106475,112028,118226,124794,131423,138536,144950,150793,158086,165386,173491,181827,190609]

Death_cases_of_India=[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,2,2,2,2,3,3,4,5,4,7,10,10,12,20,20,24,27,32,35,58,72,72,86,99,136,150,178,226,246,288,331,358,393,405,448,486,521,559,592,645,681,721,780,825,881,939,1008,1079,1154,1223,1323,1391,1566,1693,1785,1889,1985,2101,2212,2294,2415,2551,2649,2753,2871,3025,3156,3302,3434,3584,3726,3868,4024,4172,4344,4534,4711,4980,5185,5408]

Recovered_cases_of_India=[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,4,4,4,4,4,13,13,14,14,15,20,23,27,27,40,43,45,73,84,95,102,123,148,191,192,229,229,375,421,506,620,774,969,1080,1181,1359,1432,1768,2041,2463,2854,3273,3975,4370,5012,5498,5939,6523,7137,7747,8437,9068,10007,10819,11775,12847,14142,15331,16776,17887,19301,20969,22549,2442
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0,26400,27969,30258,34224,36795,39233,42309,45422,48553,51824,54385,57692,60706,64277,67749,
70920,82627,86936,91852]


R=[x + y for x, y in zip(Death_cases_of_India, Recovered_cases_of_India)]
I=[x - y for x, y in zip(Total_confirmed_cases_of_India, R)]


plt.figure();
plt.plot(Total_confirmed_cases_of_India, 'o-k');
plt.plot(Death_cases_of_India, 'o-r');
plt.plot(Recovered_cases_of_India, 'o-g');
plt.legend(['Total_confirmed_cases_of_India', 'Death_cases_of_India', 'Recovered_cases_of_India'])
plt.grid(1);
plt.yscale('log')
plt.xlabel('LOCKDOWN 0-4 (22ND FEB 2020 TO 31ST MAY 2020)')
plt.figure();


en=len(Total_confirmed_cases_of_India); st=en-7;
y=np.log(I[st:en])
t=np.array(range(st, en))
m, b = np.polyfit(t, y, 1)
plt.plot(t, (y), 'o')
plt.plot(t, (m*t + b))
plt.title('m estimate: %s' % m)
plt.grid()
plt.figure()
g=[]
for i in range(st, en-1):
    oo=(R[i+1]-R[i])/I[i]
    g.append(oo)
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plt.plot(g)
plt.grid(1)
gamma= np.mean(g);
plt.title('gamma estimate: %s' % gamma)
gamma
beta=m+gamma
print('gamma=%g beta=%g R0=%g' %(gamma, beta, beta/gamma))
```

Part 2:

```
def INDIA_SIR_COVID19_MODEL(S0,I0,R0,t0, t1, beta, gamma):
    N=S0+R0+I0;
    S=S0; R=R0; I=I0;
    SS=[S0];RR=[R0]; II=[I0];
    tt=[t0];
    dt=0.1;
    t=t0
    while t <= t1:
        dS=-beta*S*I/N
        dI=beta*S*I/N-gamma*I
        dR=gamma*I
        S=S+dt*dS;
        I=I+dt*dI;
        R=R+dt*dR;
        SS.append(S); II.append(I); RR.append(R)
        t=t+dt;
        tt.append(t)
    return(SS,II,RR,tt)


SIR=INDIA_SIR_COVID19_MODEL(1380004385, I[en-1], R[en-1], 0, 500, beta, gamma)
tt=SIR[3]; SS=SIR[0]; II=SIR[1]; RR=SIR[2];
plt.plot(tt, SS, '--r')
plt.plot(tt, II, '--g')
plt.plot(tt, RR, '--b')
plt.grid(1)
plt.legend(['S=Susceptible','I=Infected','R=Recovered'])
oo=II.index(max(II));
N=(II[0]+RR[0]+SS[0]);
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```
tmax=tt[oo]; Imax=II[oo];

inftot = RR[-1]/N

plt.xlabel('Number of Days')

plt.ylabel('Population of India')

plt.title('t_max= %g, I_max= %2.3g%%, S_inf: %2.4g%%'  % (tmax, Imax/N*100, inftot*100))
```