Gurobi Optimization MiniMax

In [1]:
```python
import gurobipy as gp
from gurobipy import *
import numpy as np
import csv
import os
import matplotlib.pyplot as plt
import warnings
import math
import pandas as pd
import random

warnings.filterwarnings("ignore") # To ignore warnings produced
```

In [2]:
```python
zips_df = pd.read_csv('Zipcode.csv')
# zips_df
zips_df = zips_df.loc[(zips_df['COUNTYNAME'] == 'ALLEGHENY') & (zips_df['population'] > 0)]
zips_df
```

Out[2]:

	OBJECTID	ZIP	NAME	ZIPTYPE	STATE	STATEFIPS	COUNTYFIPS	COUNTYNAME	S3DZIP	LAT	...	MFDU	SFI
0	4	15057	BAKERSTOWN	NON-UNIQUE	PA	42.0	42003.0	ALLEGHENY	150.0	40.361610	...	0.0	107
1	4	15206	BAKERSTOWN	NON-UNIQUE	PA	42.0	42003.0	ALLEGHENY	150.0	40.467710	...	0.0	107
2	4	15214	BAKERSTOWN	NON-UNIQUE	PA	42.0	42003.0	ALLEGHENY	150.0	40.483220	...	0.0	107
3	4	15229	BAKERSTOWN	NON-UNIQUE	PA	42.0	42003.0	ALLEGHENY	150.0	40.517330	...	0.0	107
4	4	15228	BAKERSTOWN	NON-UNIQUE	PA	42.0	42003.0	ALLEGHENY	150.0	40.368810	...	0.0	107
...	...	...	...	...	...	...	...	...	...	...	...	...	
118	65824	15047	GREENOCK	PO BOX	PA	42.0	42003.0	ALLEGHENY	150.0	40.609477	...	0.0	1
121	65828	15032	CURTISVILLE	PO BOX	PA	42.0	42003.0	ALLEGHENY	150.0	40.382820	...	346.0	4134
123	65837	15221	PITTSBURGH	NON-UNIQUE	PA	42.0	42003.0	ALLEGHENY	152.0	40.467750	...	3486.0	12256
124	65839	15205	PITTSBURGH	NON-UNIQUE	PA	42.0	42003.0	ALLEGHENY	152.0	40.483220	...	1718.0	8997
125	65841	15202	PITTSBURGH	NON-UNIQUE	PA	42.0	42003.0	ALLEGHENY	152.0	40.370729	...	2933.0	10866

96 rows × 23 columns

In [3]:
```python
zips = zips_df['ZIP'].to_list()
# zips
all_n = np.array(zips)
# # zips
# np.in1d(POD_zips, all_n)
# 0,1,5,9,10,13,15,16,21,22,24,27,29,36
# POD_zips[[0,1,5,9,10,13,15,16,21,22,24,27,29,36]]
```

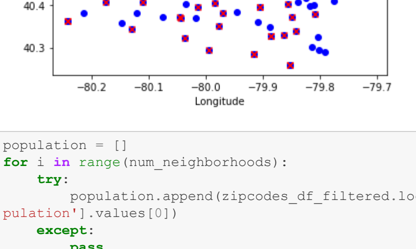
In [4]:
```python
zipcodes_path = 'pittsburgh-allegheny-county.csv'
data = np.genfromtxt(zipcodes_path, dtype=str, delimiter=',', encoding='utf-8-sig')
# neighborhoods = data.astype(np.int)
neighborhoods = all_n.astype(np.int)

POD_sites_path = 'POD Sites.xlsx'
POD_df = pd.read_excel(POD_sites_path)
POD_df = POD_df[['SCHOOL/FACILITY NAME', 'STRIP MAP']]
POD_df['ZIPCODE'] = POD_df['STRIP MAP'].apply(lambda x: str(x)[-5:])
POD_df = POD_df[:47]
POD_df

POD_zips = np.array(pd.to_numeric(POD_df.ZIPCODE).values)
print(POD_zips)
print(neighborhoods)
```

```
[15237 15236 15102 15216 15227 15106 15210 15220 15025 15108 15024 15110
 15137 15037 15238 15146 15101 15065 15216 15132 15136 15108 15228 15090
 15229 15202 15235 15214 15044 15206 15217 15239 15056 15139 15209 15133
 15057 15129 15144 15120 15136 15025 15241 15126 15122 15221 15221]
[15057 15206 15214 15229 15228 15108 15101 15146 15037 15024 15106 15236
 15237 15007 15014 15015 15018 15025 15034 15030 15035 15046 15049 15064
 15065 15082 15110 15112 15129 15131 15132 15133 15135 15137 15144 15148
 15203 15211 15213 15224 15225 15232 15239 15275 15006 15051 15223 15227
 16229 15282 15083 15088 15116 15122 15204 15216 15102 15234 15120 15017
 15215 15139 15028 15145 15104 15086 15142 15241 15226 15207 15075 15076
 15209 15243 15136 16046 15056 15045 15090 15084 15147 15235 15238 15220
 15217 15233 15143 15210 15289 15044 15126 15047 15032 15221 15205 15202]
```

In [5]:
```python
num_neighborhoods = len(neighborhoods)
num_sites = len(POD_zips)


random.seed(20)

zipcodes_df = pd.read_csv('Zipcode.csv')
# zipcodes_df = zipcodes_df.loc[zipcodes_df['type'].isin(['STANDARD', 'UNIQUE'])]
zipcodes_df = zipcodes_df.loc[(zipcodes_df['population'] > 0)]
zipcodes_df_filtered = zipcodes_df[['ZIP', 'NAME', 'LAT', 'LON', 'population']]


from math import sin, cos, sqrt, atan2, radians

def calcDistBetweenTwoPoints(pt1, pt2):
    # approximate radius of earth in km
    R = 6373.0
    lat1 = radians(pt1[0])
    lon1 = radians(pt1[1])
    lat2 = radians(pt2[0])
    lon2 = radians(pt2[1])
    dlon = lon2 - lon1
    dlat = lat2 - lat1
    a = sin(dlat / 2)**2 + cos(lat1) * cos(lat2) * sin(dlon / 2)**2
    c = 2 * atan2(sqrt(a), sqrt(1 - a))
    distance = R * c
    return(distance)

def getLatLongFromZip_graph(zipcode, df):
    lat = df.loc[df['ZIP'] == zipcode]['LAT'].values[0]
    long = df.loc[df['ZIP'] == zipcode]['LON'].values[0]
    return((lat, long))

def getLatLongFromZip(zipcode, df):
    lat = df.loc[df['ZIP'] == zipcode]['LAT'].values[0]
    long = df.loc[df['ZIP'] == zipcode]['LON'].values[0]
    return((lat, long))

problematic_n = []
problematic_s = []
distances = []
# nomi.query_postal_code()['latitude']
for i in range(num_neighborhoods):
    temp = []
    for j in range(num_sites):
        try:
#             print(POD_zips[j])
            pt1 = getLatLongFromZip(neighborhoods[i], zips_df)
#             pt1 = (nomi.query_postal_code(str(neighborhoods[i]))['latitude'], nomi.query_postal_code
(str(neighborhoods[i]))['longitude'])
#             print(pt1)
            pt2 = getLatLongFromZip(POD_zips[j], zips_df)
#             pt2 = (nomi.query_postal_code(str(POD_zips[j]))['latitude'], nomi.query_postal_code(str(P
OD_zips[j]))['longitude'])
            dist = calcDistBetweenTwoPoints(pt1, pt2)
            temp.append(dist)
        except:
            problematic_n.append(neighborhoods[i])
            problematic_s.append(POD_zips[j])
#             print(neighborhoods[i], POD_zips[j])
            print('-'*50)
            temp.append(1000000)
    distances.append(temp)
distances = np.array(distances)
# distances = np.delete(distances, (12), axis=0)
```

In [6]:
```python
POD_lats = []
POD_longs = []

for z in POD_zips:
    lat, long = getLatLongFromZip_graph(z, zips_df)
    POD_lats.append(lat)
    POD_longs.append(long)

neighborhood_lats = []
neighborhood_longs = []

for z in neighborhoods:
    lat, long = getLatLongFromZip_graph(z, zips_df)
    neighborhood_lats.append(lat)
    neighborhood_longs.append(long)


plt.scatter(neighborhood_longs, neighborhood_lats, marker='o', c = 'blue')
plt.scatter(POD_longs, POD_lats, marker='x', c = 'red')
plt.xlabel('Longitude')
plt.ylabel('Latitude')
plt.title('Neighborhoods (blue) vs possible POD sites (red)')
```

Out[6]: `Text(0.5, 1.0, 'Neighborhoods (blue) vs possible POD sites (red)')`



In [7]:
```python
population = []
for i in range(num_neighborhoods):
    try:
        population.append(zipcodes_df_filtered.loc[zipcodes_df_filtered['ZIP'] == neighborhoods[i]]['po
pulation'].values[0])
    except:
        pass

population = np.array(population)
pop_mean = np.mean(population)

#for i in range(len(population)):
#    if(population[i] == 0):
#        population[i] = pop_mean
print(population)
```

```
[ 6738 22090 12010 13410 17180 37850 24110 25680  9730  7970 16810 29410
 42230   360  2650  1290   750 15150  1350   850  1770  2360   860   310
  9890   386  3950  2650 10260  7280 14700  5460  4510  8540  3580  1860
  6410  8560  7230  7630   870  6760 20120    13   359   360  6180 26790
  4790    16   900   631 13950 17260  6820 19990 28950 12670 15350 14880
 11150  6080   170  5720  6020   560  1860 22040 11930  8780   207   810
 10970 13340 20030 18170   950  3500 23900  8360 13980 30560 12850 16460
 21290  2120 21220 20140   123 29140  6730   378   244 23860 20320 17220]
```

In [8]:
```python
population.shape
```

Out[8]: `(96,)`

Find the min max distance possible

In [9]:
```python
# MODEL INITIALIZATION
m1 = Model()
sizes = range(3)
zipcodes = range(distances.shape[0])
sites = range(distances.shape[1])
days = range(25)

# CONSTANTS
D = distances
p = population
total_pop = population.sum()
e = np.array([72, 85, 100])
o = 20000
v = 50
f = 8000
r = 206.76
h = 12.5
C = 1370

# DECISION VARIABLES
A = m1.addVars(zipcodes, sites, vtype = GRB.BINARY)
S = m1.addVars(sites, vtype = GRB.BINARY)
M = m1.addVars(sites, vtype = GRB.BINARY)
L = m1.addVars(sites, vtype = GRB.BINARY)
U = m1.addVars(sites, days, vtype = GRB.BINARY)
X = m1.addVars(sites, days)#, vtype = GRB.INTEGER)
I = m1.addVars(sites, days)#, vtype = GRB.INTEGER)

# OBJECTIVE

MAX = m1.addVar(lb = 0.0)
m1.setObjective(MAX)
m1.modelSense = GRB.MINIMIZE

# CONSTRAINTS
for i in zipcodes:
    m1.addConstr(sum(A[i,j] for j in sites) == 1)

    for j in sites:
        m1.addConstr(MAX >= D[i,j]*A[i,j])
        m1.addConstr(A[i,j] <= S[j] + M[j] + L[j])
        m1.addConstr(A[i,j] >= 0)

for j in sites:
    assigned_pop = sum(A[i,j] * p[i] for i in zipcodes)
    m1.addConstr(S[j] + M[j] + L[j] <= 1)
    m1.addConstr(sum(e[0]*X[j,t] for t in days) >= assigned_pop - (1-S[j])*total_pop)
    m1.addConstr(sum(e[1]*X[j,t] for t in days) >= assigned_pop - (1-M[j])*total_pop)
    m1.addConstr(sum(e[2]*X[j,t] for t in days) >= assigned_pop)
    m1.addConstr(S[j] >= 0)
    m1.addConstr(M[j] >= 0)
    m1.addConstr(L[j] >= 0)

    administered = [0,0,0]
    for t in days:
        administered[0] += e[0]*X[j,t]
        administered[1] += e[1]*X[j,t]
        administered[2] += e[2]*X[j,t]
        m1.addConstr(X[j,t] >= 10*M[j] + 20*L[j] - 20*(1-U[j,t]))
        m1.addConstr(X[j,t] <= 10*S[j] + 20*M[j] + C*L[j]) #The third term is redundant
        m1.addConstr(X[j,t] <= C*U[j,t])
        m1.addConstr(U[j,t] <= S[j] + M[j] + L[j])
        m1.addConstr(I[j,t] + (1-S[j])*total_pop >= assigned_pop - administered[0])
        m1.addConstr(I[j,t] + (1-M[j])*total_pop >= assigned_pop - administered[1])
        m1.addConstr(I[j,t] + (1-L[j])*total_pop >= assigned_pop - administered[2])
        m1.addConstr(X[j,t] >= 0)
        m1.addConstr(I[j,t] >= 0)
        m1.addConstr(U[j,t] >= 0)

for t in days:
    m1.addConstr(sum(X[j,t] for j in sites) <= C)
```

```
Academic license - for non-commercial use only - expires 2022-08-29
Using license file C:\Users\Ben\gurobi.lic
```

In [10]:
```python
#m1.Params.MIPGap = 0.1
m1.Params.TimeLimit = 20*60
m1.optimize()
```

```
Changed value of parameter TimeLimit to 1200.0
   Prev: inf  Min: 0.0  Max: inf  Default: inf
Gurobi Optimizer version 9.1.2 build v9.1.2rc0 (win64)
Thread count: 6 physical cores, 12 logical processors, using up to 12 threads
Optimize a model with 25736 rows, 8179 columns and 465901 nonzeros
Model fingerprint: 0x52a4fd94
Variable types: 2351 continuous, 5828 integer (5828 binary)
Coefficient statistics:
  Matrix range     [2e-01, 1e+06]
  Objective range  [1e+00, 1e+00]
  Bounds range     [1e+00, 1e+00]
  RHS range        [1e+00, 1e+06]
Presolve removed 11853 rows and 1175 columns
Presolve time: 0.30s
Presolved: 13883 rows, 7004 columns, 66250 nonzeros
Variable types: 1176 continuous, 5828 integer (5828 binary)
Found heuristic solution: objective 47.6903713
Found heuristic solution: objective 35.9605456
Found heuristic solution: objective 32.0191374

Root relaxation: objective 2.849850e+00, 1865 iterations, 0.12 seconds

    Nodes    |    Current Node    |     Objective Bounds      |     Work
 Expl Unexpl |  Obj  Depth IntInf | Incumbent    BestBd   Gap | It/Node Time

     0     0    2.84985    0  228   32.01914    2.84985  91.1%     -    0s
H    0     0                      31.3664648    2.84985  90.9%     -    0s
H    0     0                      28.7704195    2.84985  90.1%     -    0s
H    0     0                      17.5052689    2.84985  83.7%     -    0s
H    0     0                      14.6579122    2.84985  80.6%     -    0s

Cutting planes:
  MIR: 6
  Flow cover: 6
  GUB cover: 1
  RLT: 32
  Relax-and-lift: 24

Explored 1 nodes (7170 simplex iterations) in 1.04 seconds
Thread count was 12 (of 12 available processors)

Solution count 7: 14.6579 17.5053 28.7704 ... 47.6904

Optimal solution found (tolerance 1.00e-04)
Best objective 1.465791215778e+01, best bound 1.465791215778e+01, gap 0.0000%
```

In [11]:
```python
m1.objval
```

Out[11]: `14.657912157781494`

The minimum max distance possible is 14.66

In [12]:
```python
num_sites = 0
for j in sites:
    if (S[j].x + M[j].x + L[j].x) > 0:
        num_sites += 1
print(num_sites)
```

```
46
```

Minimizing distance while keeping cost at a minimum

In [13]:
```python
distances.max(0).min()
```

Out[13]: `30.520364383667598`

In [14]:
```python
np.argmin(distances.max(0))
```

Out[14]: `29`

Use only one site, site 29

Minimizing Cost while holding max distance at minimum

In [15]:
```python
m1.addConstr(MAX <= m1.objval)
m1.setObjective(o*sum((S[j] + M[j] + L[j]) for j in sites)
                + v*sum(A[i,j]*p[i] for i in zipcodes for j in sites)
                + sum(r*X[j,t] + h*I[j,t] + f*U[j,t] for j in sites for t in days))
#m1.Params.MIPGap = 0.1
m1.Params.TimeLimit = 40*60
m1.optimize()
m1.objval
```

```
Changed value of parameter TimeLimit to 2400.0
   Prev: 1200.0  Min: 0.0  Max: inf  Default: inf
Gurobi Optimizer version 9.1.2 build v9.1.2rc0 (win64)
Thread count: 6 physical cores, 12 logical processors, using up to 12 threads
Optimize a model with 25737 rows, 8179 columns and 465902 nonzeros
Model fingerprint: 0xec4dd7f8
Variable types: 2351 continuous, 5828 integer (5828 binary)
Coefficient statistics:
  Matrix range     [2e-01, 1e+06]
  Objective range  [1e+01, 2e+06]
  Bounds range     [1e+00, 1e+00]
  RHS range        [1e+00, 1e+06]

MIP start from previous solve produced solution with objective 1.34837e+08 (0.08s)
Loaded MIP start from previous solve with objective 1.34837e+08

Presolve removed 15880 rows and 3042 columns
Presolve time: 0.45s
Presolved: 9857 rows, 5137 columns, 189551 nonzeros
Variable types: 2333 continuous, 2804 integer (2804 binary)

Root relaxation: objective 5.248864e+07, 8862 iterations, 0.81 seconds

    Nodes    |    Current Node    |     Objective Bounds      |     Work
 Expl Unexpl |  Obj  Depth IntInf | Incumbent    BestBd   Gap | It/Node Time

     0     0 5.2489e+07    0  159 1.3484e+08 5.2489e+07  61.1%     -    1s
H    0     0                    1.341447e+08 5.2489e+07  60.9%     -    1s
H    0     0                    1.341047e+08 5.2489e+07  60.9%     -    2s
H    0     0                    1.286894e+08 5.2489e+07  59.2%     -    2s
     0     0 5.2489e+07    0  144 1.2869e+08 5.2489e+07  59.2%     -    2s
     0     0 5.2489e+07    0  140 1.2869e+08 5.2489e+07  59.2%     -    2s
H    0     0                    9.348749e+07 5.2489e+07  43.9%     -    3s
     0     0 5.2489e+07    0  127 9.3487e+07 5.2489e+07  43.9%     -    3s
     0     0 5.2489e+07    0  239 9.3487e+07 5.2489e+07  43.9%     -    3s
     0     0 5.2489e+07    0  231 9.3487e+07 5.2489e+07  43.9%     -    4s
     0     0 5.2489e+07    0  229 9.3487e+07 5.2489e+07  43.9%     -    4s
     0     0 5.2489e+07    0  227 9.3487e+07 5.2489e+07  43.9%     -    4s
     0     0 5.2490e+07    0  280 9.3487e+07 5.2490e+07  43.9%     -    5s
     0     0 5.2491e+07    0  316 9.3487e+07 5.2491e+07  43.9%     -    5s
     0     0 5.2491e+07    0  298 9.3487e+07 5.2491e+07  43.9%     -    5s
     0     0 5.2491e+07    0  299 9.3487e+07 5.2491e+07  43.9%     -    5s
     0     0 5.2491e+07    0  323 9.3487e+07 5.2491e+07  43.9%     -    5s
     0     0 5.2491e+07    0  322 9.3487e+07 5.2491e+07  43.9%     -    5s
     0     0 5.2491e+07    0  324 9.3487e+07 5.2491e+07  43.9%     -    5s
     0     0 5.2492e+07    0  321 9.3487e+07 5.2492e+07  43.9%     -    5s
     0     0 5.2492e+07    0  388 9.3487e+07 5.2492e+07  43.9%     -    6s
     0     0 5.2492e+07    0  400 9.3487e+07 5.2492e+07  43.9%     -    6s
     0     0 5.2492e+07    0  408 9.3487e+07 5.2492e+07  43.9%     -    6s
H    0     0                    9.251929e+07 5.2492e+07  43.3%     -    6s
     0     0 5.2492e+07    0  456 9.2519e+07 5.2492e+07  43.3%     -    6s
     0     0 5.2492e+07    0  406 9.2519e+07 5.2492e+07  43.3%     -    6s
     0     0 5.2492e+07    0  360 9.2519e+07 5.2492e+07  43.3%     -    6s
     0     0 5.2493e+07    0  321 9.2519e+07 5.2493e+07  43.3%     -    6s
     0     0 5.2493e+07    0  320 9.2519e+07 5.2493e+07  43.3%     -    7s
     0     0 5.2493e+07    0  347 9.2519e+07 5.2493e+07  43.3%     -    7s
     0     0 5.2493e+07    0  347 9.2519e+07 5.2493e+07  43.3%     -    7s
     0     0 5.2493e+07    0  384 9.2519e+07 5.2493e+07  43.3%     -    7s
     0     0 5.2493e+07    0  342 9.2519e+07 5.2493e+07  43.3%     -    7s
     0     0 5.2493e+07    0  495 9.2519e+07 5.2493e+07  43.3%     -    7s
     0     0 5.2493e+07    0  436 9.2519e+07 5.2493e+07  43.3%     -    7s
     0     0 5.2493e+07    0  499 9.2519e+07 5.2493e+07  43.3%     -    7s
     0     0 5.2493e+07    0  498 9.2519e+07 5.2493e+07  43.3%     -    7s
     0     0 5.2494e+07    0  521 9.2519e+07 5.2494e+07  43.3%     -    8s
     0     0 5.2494e+07    0  521 9.2519e+07 5.2494e+07  43.3%     -    8s
     0     0 5.2495e+07    0  504 9.2519e+07 5.2495e+07  43.3%     -    8s
     0     0 5.2495e+07    0  502 9.2519e+07 5.2495e+07  43.3%     -    8s
     0     0 5.2495e+07    0  544 9.2519e+07 5.2495e+07  43.3%     -    8s
     0     0 5.2495e+07    0  525 9.2519e+07 5.2495e+07  43.3%     -    8s
     0     0 5.2495e+07    0  525 9.2519e+07 5.2495e+07  43.3%     -    8s
     0     0 5.2496e+07    0  524 9.2519e+07 5.2496e+07  43.3%     -    9s
     0     0 5.2496e+07    0  556 9.2519e+07 5.2496e+07  43.3%     -    9s
     0     0 5.2496e+07    0  551 9.2519e+07 5.2496e+07  43.3%     -    9s
     0     0 5.2496e+07    0  554 9.2519e+07 5.2496e+07  43.3%     -    9s
     0     0 5.2497e+07    0  412 9.2519e+07 5.2497e+07  43.3%     -    9s
     0     0 5.2497e+07    0  329 9.2519e+07 5.2497e+07  43.3%     -    9s
     0     0 5.2497e+07    0  390 9.2519e+07 5.2497e+07  43.3%     -    9s
     0     0 5.2497e+07    0  391 9.2519e+07 5.2497e+07  43.3%     -    9s
     0     0 5.2497e+07    0  395 9.2519e+07 5.2497e+07  43.3%     -    9s
     0     0 5.2497e+07    0  406 9.2519e+07 5.2497e+07  43.3%     -   10s
     0     0 5.2497e+07    0  393 9.2519e+07 5.2497e+07  43.3%     -   10s
     0     0 5.2497e+07    0  477 9.2519e+07 5.2497e+07  43.3%     -   10s
     0     0 5.2497e+07    0  478 9.2519e+07 5.2497e+07  43.3%     -   10s
     0     0 5.2498e+07    0  424 9.2519e+07 5.2498e+07  43.3%     -   10s
     0     0 5.2498e+07    0  447 9.2519e+07 5.2498e+07  43.3%     -   10s
     0     0 5.2498e+07    0  446 9.2519e+07 5.2498e+07  43.3%     -   11s
     0     0 5.2498e+07    0  441 9.2519e+07 5.2498e+07  43.3%     -   11s
     0     0 5.2498e+07    0  485 9.2519e+07 5.2498e+07  43.3%     -   11s
     0     0 5.2498e+07    0  436 9.2519e+07 5.2498e+07  43.3%     -   11s
     0     0 5.2498e+07    0  428 9.2519e+07 5.2498e+07  43.3%     -   11s
     0     0 5.2499e+07    0  358 9.2519e+07 5.2499e+07  43.3%     -   11s
     0     0 5.2499e+07    0  446 9.2519e+07 5.2499e+07  43.3%     -   11s
     0     0 5.2499e+07    0  396 9.2519e+07 5.2499e+07  43.3%     -   11s
     0     0 5.2499e+07    0  443 9.2519e+07 5.2499e+07  43.3%     -   12s
     0     0 5.2499e+07    0  546 9.2519e+07 5.2499e+07  43.3%     -   12s
     0     0 5.2500e+07    0  449 9.2519e+07 5.2500e+07  43.3%     -   12s
     0     0 5.2500e+07    0  485 9.2519e+07 5.2500e+07  43.3%     -   12s
     0     0 5.2500e+07    0  525 9.2519e+07 5.2500e+07  43.3%     -   12s
     0     0 5.2500e+07    0  498 9.2519e+07 5.2500e+07  43.3%     -   12s
     0     0 5.2500e+07    0  495 9.2519e+07 5.2500e+07  43.3%     -   12s
     0     0 5.2500e+07    0  496 9.2519e+07 5.2500e+07  43.3%     -   13s
     0     0 5.2500e+07    0  456 9.2519e+07 5.2500e+07  43.3%     -   13s
     0     0 5.2500e+07    0  440 9.2519e+07 5.2500e+07  43.3%     -   13s
     0     0 5.2500e+07    0  461 9.2519e+07 5.2500e+07  43.3%     -   13s
     0     0 5.2500e+07    0  441 9.2519e+07 5.2500e+07  43.3%     -   13s
     0     0 5.2501e+07    0  462 9.2519e+07 5.2501e+07  43.3%     -   13s
     0     0 5.2502e+07    0  368 9.2519e+07 5.2502e+07  43.3%     -   13s
     0     0 5.2502e+07    0  407 9.2519e+07 5.2502e+07  43.3%     -   14s
     0     0 5.2502e+07    0  376 9.2519e+07 5.2502e+07  43.3%     -   14s
H    0     0                    9.251449e+07 5.2502e+07  43.2%     -   14s
     0     0 5.2502e+07    0  372 9.2514e+07 5.2502e+07  43.2%     -   14s
     0     0 5.2502e+07    0  397 9.2514e+07 5.2502e+07  43.2%     -   14s
     0     0 5.2502e+07    0  330 9.2514e+07 5.2502e+07  43.2%     -   14s
     0     0 5.2502e+07    0  361 9.2514e+07 5.2502e+07  43.2%     -   14s
     0     0 5.2503e+07    0  344 9.2514e+07 5.2503e+07  43.2%     -   14s
     0     0 5.2503e+07    0  420 9.2514e+07 5.2503e+07  43.2%     -   14s
     0     0 5.2503e+07    0  421 9.2514e+07 5.2503e+07  43.2%     -   14s
     0     0 5.2503e+07    0  533 9.2514e+07 5.2503e+07  43.2%     -   15s
     0     0 5.2503e+07    0  368 9.2514e+07 5.2503e+07  43.2%     -   15s
     0     0 5.2503e+07    0  512 9.2514e+07 5.2503e+07  43.2%     -   15s
     0     0 5.2503e+07    0  546 9.2514e+07 5.2503e+07  43.2%     -   15s
H    0     0                    9.251289e+07 5.2503e+07  43.2%     -   15s
     0     0 5.2503e+07    0  518 9.2513e+07 5.2503e+07  43.2%     -   15s
     0     0 5.2503e+07    0  333 9.2513e+07 5.2503e+07  43.2%     -   15s
     0     0 5.2503e+07    0  401 9.2513e+07 5.2503e+07  43.2%     -   16s
     0     0 5.2503e+07    0  567 9.2513e+07 5.2503e+07  43.2%     -   16s
     0     0 5.2503e+07    0  411 9.2513e+07 5.2503e+07  43.2%     -   16s
     0     0 5.2503e+07    0  386 9.2513e+07 5.2503e+07  43.2%     -   16s
     0     0 5.2503e+07    0  422 9.2513e+07 5.2503e+07  43.2%     -   16s
     0     0 5.2504e+07    0  596 9.2513e+07 5.2504e+07  43.2%     -   16s
     0     0 5.2504e+07    0  614 9.2513e+07 5.2504e+07  43.2%     -   16s
     0     0 5.2504e+07    0  601 9.2513e+07 5.2504e+07  43.2%     -   16s
     0     0 5.2504e+07    0  593 9.2513e+07 5.2504e+07  43.2%     -   17s
     0     0 5.2504e+07    0  594 9.2513e+07 5.2504e+07  43.2%     -   17s
     0     0 5.2504e+07    0  611 9.2513e+07 5.2504e+07  43.2%     -   17s
     0     0 5.2504e+07    0  605 9.2513e+07 5.2504e+07  43.2%     -   17s
     0     0 5.2504e+07    0  599 9.2513e+07 5.2504e+07  43.2%     -   17s
     0     0 5.2504e+07    0  624 9.2513e+07 5.2504e+07  43.2%     -   17s
     0     0 5.2504e+07    0  493 9.2513e+07 5.2504e+07  43.2%     -   18s
     0     0 5.2504e+07    0  560 9.2513e+07 5.2504e+07  43.2%     -   18s
     0     0 5.2504e+07    0  580 9.2513e+07 5.2504e+07  43.2%     -   18s
     0     0 5.2504e+07    0  458 9.2513e+07 5.2504e+07  43.2%     -   18s
     0     0 5.2504e+07    0  563 9.2513e+07 5.2504e+07  43.2%     -   18s
     0     0 5.2504e+07    0  473 9.2513e+07 5.2504e+07  43.2%     -   18s
     0     0 5.2504e+07    0  467 9.2513e+07 5.2504e+07  43.2%     -   18s
     0     0 5.2504e+07    0  423 9.2513e+07 5.2504e+07  43.2%     -   18s
     0     0 5.2505e+07    0  427 9.2513e+07 5.2505e+07  43.2%     -   19s
     0     0 5.2505e+07    0  450 9.2513e+07 5.2505e+07  43.2%     -   19s
     0     0 5.2505e+07    0  424 9.2513e+07 5.2505e+07  43.2%     -   19s
     0     0 5.2505e+07    0  450 9.2513e+07 5.2505e+07  43.2%     -   19s
     0     0 5.2505e+07    0  487 9.2513e+07 5.2505e+07  43.2%     -   19s
     0     0 5.2505e+07    0  488 9.2513e+07 5.2505e+07  43.2%     -   20s
     0     0 5.2505e+07    0  531 9.2513e+07 5.2505e+07  43.2%     -   20s
H    0     0                    9.250730e+07 5.2505e+07  43.2%     -   20s
     0     0 5.2505e+07    0  523 9.2507e+07 5.2505e+07  43.2%     -   20s
     0     0 5.2505e+07    0  532 9.2507e+07 5.2505e+07  43.2%     -   20s
     0     0 5.2505e+07    0  548 9.2507e+07 5.2505e+07  43.2%     -   20s
     0     0 5.2505e+07    0  545 9.2507e+07 5.2505e+07  43.2%     -   20s
     0     0 5.2505e+07    0  550 9.2507e+07 5.2505e+07  43.2%     -   21s
     0     0 5.2505e+07    0  537 9.2507e+07 5.2505e+07  43.2%     -   21s
     0     0 5.2505e+07    0  562 9.2507e+07 5.2505e+07  43.2%     -   21s
     0     0 5.2506e+07    0  586 9.2507e+07 5.2506e+07  43.2%     -   21s
     0     0 5.2506e+07    0  526 9.2507e+07 5.2506e+07  43.2%     -   21s
H    0     0                    9.250727e+07 5.2506e+07  43.2%     -   21s
     0     0 5.2506e+07    0  441 9.2507e+07 5.2506e+07  43.2%     -   21s
     0     0 5.2506e+07    0  497 9.2507e+07 5.2506e+07  43.2%     -   22s
     0     0 5.2506e+07    0  504 9.2507e+07 5.2506e+07  43.2%     -   22s
     0     0 5.2506e+07    0  487 9.2507e+07 5.2506e+07  43.2%     -   22s
H    0     0                    9.250726e+07 5.2506e+07  43.2%     -   23s
     0     2 5.2506e+07    0  484 9.2507e+07 5.2506e+07  43.2%     -   23s
    13    20 5.2507e+07    4  509 9.2507e+07 5.2506e+07  43.2%   696   25s
H   38    40                    9.250726e+07 5.2506e+07  43.2%   695   26s
H  169   181                    9.250421e+07 5.2506e+07  43.2%   374   29s
   240   257 infeasible   41      9.2504e+07 5.2506e+07  43.2%   357   30s
   632   572 6.9748e+07   82   97 9.2504e+07 5.2506e+07  43.2%   225   36s
H  639   572                    9.250421e+07 5.2506e+07  43.2%   224   36s
  1212  1293 8.5328e+07  169  184 9.2504e+07 5.2506e+07  43.2%   169   40s
  2414  2308 5.2509e+07   10  326 9.2504e+07 5.2506e+07  43.2%   118   45s
  2927  2712 5.2589e+07   57  116 9.2504e+07 5.2506e+07  43.2%   124   61s
  3018  2713 9.0928e+07  255  487 9.2504e+07 5.2506e+07  43.2%   125   75s
  3022  2716 7.0296e+07   74  439 9.2504e+07 5.2506e+07  43.2%   125   80s
  3036  2725 7.5019e+07  148  449 9.2504e+07 5.2513e+07  43.2%   124   86s
  3044  2730 6.3125e+07  105  422 9.2504e+07 5.2520e+07  43.2%   124   90s
  3060  2741 8.8571e+07  212  505 9.2504e+07 5.2525e+07  43.2%   123   95s
  3073  2750 8.6406e+07  189  526 9.2504e+07 5.2533e+07  43.2%   123  100s
  3088  2760 8.3363e+07  180  458 9.2504e+07 5.2539e+07  43.2%   122  105s
  3098  2766 5.7405e+07   92  494 9.2504e+07 5.2542e+07  43.2%   122  110s
  3110  2774 8.3722e+07  112  679 9.2504e+07 5.2544e+07  43.2%   121  115s
  3114  2777 7.6630e+07  106  633 9.2504e+07 5.2546e+07  43.2%   121  120s
  3124  2784 8.5098e+07  200  587 9.2504e+07 5.2548e+07  43.2%   121  125s
  3134  2790 8.3281e+07  157  637 9.2504e+07 5.2549e+07  43.2%   121  130s
  3140  2794 6.3751e+07   69  568 9.2504e+07 5.2550e+07  43.2%   120  135s
  3149  2800 5.2552e+07   25  579 9.2504e+07 5.2552e+07  43.2%   120  143s
  3153  2803 6.4124e+07   40  683 9.2504e+07 5.2552e+07  43.2%   120  145s
  3165  2811 8.8512e+07  229  514 9.2504e+07 5.2553e+07  43.2%   119  150s
  3176  2818 8.5394e+07  146  612 9.2504e+07 5.2554e+07  43.2%   119  155s
  3183  2823 6.2807e+07   58  539 9.2504e+07 5.2554e+07  43.2%   119  160s
H 3188  2681                    9.250332e+07 5.2555e+07  43.2%   118  164s
H 3188  2544                    9.250331e+07 5.2555e+07  43.2%   118  164s
  3190  2546 8.1588e+07  102  586 9.2503e+07 5.2555e+07  43.2%   118  165s
H 3192  2417                    9.250330e+07 5.2555e+07  43.2%   118  165s
H 3196  2296                    9.250329e+07 5.2555e+07  43.2%   118  166s
  3202  2300 6.8232e+07   70  573 9.2503e+07 5.2555e+07  43.2%   118  170s
  3216  2309 6.2589e+07   52  631 9.2503e+07 5.2556e+07  43.2%   117  175s
H 3217  2191                    9.250329e+07 5.2556e+07  43.2%   117  177s
  3223  2195 9.1933e+07  302  563 9.2503e+07 5.2556e+07  43.2%   117  182s
  3235  2203 8.3241e+07  149  585 9.2503e+07 5.2557e+07  43.2%   117  185s
  3246  2210 8.7966e+07  225  649 9.2503e+07 5.2557e+07  43.2%   116  191s
  3255  2216 5.2558e+07   32  667 9.2503e+07 5.2558e+07  43.2%   116  195s
  3265  2223 8.8512e+07  229  762 9.2503e+07 5.2558e+07  43.2%   116  200s
  3272  2227 6.8240e+07   56  729 9.2503e+07 5.2558e+07  43.2%   115  206s
  3279  2232 7.4457e+07  131  618 9.2503e+07 5.2559e+07  43.2%   115  210s
  3289  2239 8.7513e+07  250  706 9.2503e+07 5.2559e+07  43.2%   115  215s
  3296  2243 6.9724e+07   79  563 9.2503e+07 5.2559e+07  43.2%   115  220s
  3302  2247 6.8232e+07   70  606 9.2503e+07 5.2559e+07  43.2%   114  226s
  3311  2253 8.6186e+07  151  641 9.2503e+07 5.2559e+07  43.2%   114  230s
  3319  2259 5.4444e+07   42  697 9.2503e+07 5.2559e+07  43.2%   114  235s
  3325  2264 5.2559e+07   34  224 9.2503e+07 5.2559e+07  43.2%   198  240s
  3330  2267 7.9836e+07  136  713 9.2503e+07 5.2559e+07  43.2%   198  246s
  3334  2270 8.3281e+07  157  664 9.2503e+07 5.2559e+07  43.2%   197  250s
  3339  2273 8.9402e+07  205  666 9.2503e+07 5.2559e+07  43.2%   197  255s
  3350  2280 5.4456e+07   42  767 9.2503e+07 5.2559e+07  43.2%   196  260s
  3353  2282 6.4124e+07   40  687 9.2503e+07 5.2560e+07  43.2%   196  265s
  3363  2289 8.8346e+07  197  702 9.2503e+07 5.2561e+07  43.2%   196  270s
  3372  2295 6.8240e+07   56  681 9.2503e+07 5.2562e+07  43.2%   195  275s
  3382  2302 8.0277e+07  146  735 9.2503e+07 5.2562e+07  43.2%   195  280s
  3392  2308 9.1235e+07  245  810 9.2503e+07 5.2563e+07  43.2%   194  285s
  3404  2316 8.3741e+07  185  687 9.2503e+07 5.2565e+07  43.2%   193  290s
  3410  2320 8.3722e+07  112  752 9.2503e+07 5.2566e+07  43.2%   193  295s
  3418  2326 9.0928e+07  255  752 9.2503e+07 5.2566e+07  43.2%   192  300s
  3429  2333 6.0992e+07   92  602 9.2503e+07 5.2566e+07  43.2%   192  305s
  3439  2340 8.9402e+07  205  782 9.2503e+07 5.2566e+07  43.2%   191  311s
  3445  2344 6.8486e+07   53  813 9.2503e+07 5.2567e+07  43.2%   191  315s
  3453  2349 6.4124e+07   40  623 9.2503e+07 5.2567e+07  43.2%   191  321s
  3461  2354 5.2567e+07   23  838 9.2503e+07 5.2567e+07  43.2%   190  327s
  3467  2358 5.4609e+07   50  838 9.2503e+07 5.2568e+07  43.2%   190  330s
  3475  2364 7.6021e+07  107  766 9.2503e+07 5.2568e+07  43.2%   189  335s
  3482  2368 8.0277e+07  146  898 9.2503e+07 5.2568e+07  43.2%   189  340s
  3489  2373 8.7513e+07  250  869 9.2503e+07 5.2568e+07  43.2%   189  345s
  3497  2378 8.1429e+07   95  847 9.2503e+07 5.2569e+07  43.2%   188  351s
  3506  2384 5.2738e+07   58  885 9.2503e+07 5.2569e+07  43.2%   188  355s
  3512  2388 5.6140e+07   74  886 9.2503e+07 5.2570e+07  43.2%   187  360s
  3520  2394 8.8203e+07  197  796 9.2503e+07 5.2570e+07  43.2%   187  366s
  3529  2400 6.0992e+07   92  811 9.2503e+07 5.2570e+07  43.2%   186  370s
  3539  2406 8.9402e+07  205  827 9.2503e+07 5.2570e+07  43.2%   186  376s
  3546  2411 8.7966e+07  225  726 9.2503e+07 5.2571e+07  43.2%   186  380s
  3553  2416 6.4124e+07   40  802 9.2503e+07 5.2571e+07  43.2%   185  385s
  3560  2420 8.8571e+07  212  678 9.2503e+07 5.2571e+07  43.2%   185  390s
  3569  2426 5.2572e+07   12  846 9.2503e+07 5.2572e+07  43.2%   184  395s
  3575  2430 7.6021e+07  107  786 9.2503e+07 5.2572e+07  43.2%   184  401s
  3582  2435 8.0277e+07  146  854 9.2503e+07 5.2572e+07  43.2%   184  405s
  3590  2440 8.1588e+07  102  825 9.2503e+07 5.2572e+07  43.2%   183  410s
  3598  2446 5.7405e+07   92  798 9.2503e+07 5.2573e+07  43.2%   183  416s
  3604  2450 8.3741e+07  185  812 9.2503e+07 5.2573e+07  43.2%   183  420s
  3609  2454 5.2573e+07   47  375 9.2503e+07 5.2573e+07  43.2%   248  425s
  3613  2457 7.6630e+07  105  511 9.2503e+07 5.2573e+07  43.2%   248  430s
  3617  2459 6.9751e+07   84  665 9.2503e+07 5.2573e+07  43.2%   248  436s
  3619  2461 5.4444e+07   42  602 9.2503e+07 5.2573e+07  43.2%   248  440s
  3624  2464 8.5098e+07  200  687 9.2503e+07 5.2573e+07  43.2%   247  445s
  3637  2473 8.8961e+07  276  720 9.2503e+07 5.2573e+07  43.2%   247  451s
  3641  2475 8.3987e+07  209  643 9.2503e+07 5.2573e+07  43.2%   246  455s
  3649  2481 5.2574e+07   25  756 9.2503e+07 5.2574e+07  43.2%   246  460s
  3656  2485 8.9101e+07  248  727 9.2503e+07 5.2574e+07  43.2%   245  465s
  3665  2491 8.8512e+07  229  631 9.2503e+07 5.2575e+07  43.2%   245  470s
  3673  2497 8.6406e+07  189  755 9.2503e+07 5.2575e+07  43.2%   244  475s
  3682  2503 8.0277e+07  146  828 9.2503e+07 5.2576e+07  43.2%   244  480s
  3691  2509 5.4491e+07   72  719 9.2503e+07 5.2576e+07  43.2%   243  485s
  3701  2515 7.9817e+07  117  673 9.2503e+07 5.2578e+07  43.2%   242  491s
  3710  2521 8.3722e+07  112  621 9.2503e+07 5.2579e+07  43.2%   242  495s
  3719  2527 5.4444e+07   42  668 9.2503e+07 5.2579e+07  43.2%   241  500s
  3733  2537 6.6878e+07   98  708 9.2503e+07 5.2580e+07  43.2%   240  506s
  3740  2541 6.3751e+07   69  599 9.2503e+07 5.2580e+07  43.2%   240  511s
  3749  2547 5.2581e+07   25  674 9.2503e+07 5.2581e+07  43.2%   239  515s
  3760  2555 8.8571e+07  212  514 9.2503e+07 5.2581e+07  43.2%   238  520s
  3771  2562 9.1098e+07  223  655 9.2503e+07 5.2581e+07  43.2%   238  526s
  3779  2569 7.4457e+07  131  487 9.2503e+07 5.2581e+07  43.2%   289  530s
  3783  2572 6.2807e+07   58  436 9.2503e+07 5.2581e+07  43.2%   289  535s
  3787  2574 8.8937e+07  242  565 9.2503e+07 5.2581e+07  43.2%   288  540s
  3791  2577 5.4491e+07   72  617 9.2503e+07 5.2581e+07  43.2%   288  545s
  3798  2582 5.7405e+07   92  770 9.2503e+07 5.2581e+07  43.2%   287  550s
  3809  2589 5.2581e+07   47  532 9.2503e+07 5.2581e+07  43.2%   287  555s
  3817  2594 6.9751e+07   84  649 9.2503e+07 5.2582e+07  43.2%   286  560s
  3828  2602 7.4928e+07  140  578 9.2503e+07 5.2582e+07  43.2%   285  565s
  3835  2606 8.3241e+07  149  693 9.2503e+07 5.2582e+07  43.2%   285  570s
  3844  2612 6.3125e+07  105  614 9.2503e+07 5.2582e+07  43.2%   284  575s
  3848  2615 6.5991e+07   83  501 9.2503e+07 5.2582e+07  43.2%   284  580s
  3853  2618 6.4124e+07   40  563 9.2503e+07 5.2582e+07  43.2%   283  585s
  3854  2622 5.2583e+07   49  659 9.2503e+07 5.2583e+07  43.2%   212  609s
  3856  2625 5.2585e+07   50  691 9.2503e+07 5.2584e+07  43.2%   213  643s
  3860  2630 5.2585e+07   51  678 9.2503e+07 5.2585e+07  43.2%   214  653s
  3866  2634 5.2586e+07   52  760 9.2503e+07 5.2585e+07  43.2%   219  661s
  3872  2638 5.2586e+07   52  550 9.2503e+07 5.2586e+07  43.2%   225  666s
  3884  2651 5.2587e+07   53  371 9.2503e+07 5.2586e+07  43.2%   230  671s
  3905  2663 5.2589e+07   55  344 9.2503e+07 5.2586e+07  43.2%   237  676s
  3914  2671 5.2587e+07   56  410 9.2503e+07 5.2586e+07  43.2%   240  680s
  3925  2676 5.2611e+07   57  482 9.2503e+07 5.2586e+07  43.2%   248  685s
  3946  2691 5.2609e+07   59  377 9.2503e+07 5.2586e+07  43.2%   258  691s
  3970  2709 5.2598e+07   61  351 9.2503e+07 5.2586e+07  43.2%   266  697s
  3982  2739 5.2598e+07   62  211 9.2503e+07 5.2586e+07  43.2%   274  702s
  4016  2766 5.2644e+07   66  255 9.2503e+07 5.2586e+07  43.2%   287  707s
  4054  2796 5.2604e+07   70  182 9.2503e+07 5.2586e+07  43.2%   297  711s
  4130  2853 5.2610e+07   78  184 9.2503e+07 5.2586e+07  43.2%   317  717s
  4179  2891 5.2614e+07   85  103 9.2503e+07 5.2586e+07  43.2%   327  721s
  4294  2970 5.2644e+07  102  108 9.2503e+07 5.2586e+07  43.2%   341  726s
  4411  3068 5.3788e+07  122   62 9.2503e+07 5.2586e+07  43.2%   349  732s
  4488  3123 5.3946e+07  134   99 9.2503e+07 5.2586e+07  43.2%   352  737s
  4568  3147 5.4692e+07  144   86 9.2503e+07 5.2586e+07  43.2%   353  743s
  4619  3219 5.6624e+07  150  108 9.2503e+07 5.2586e+07  43.2%   355  746s
  4819  3357 5.9163e+07  166  120 9.2503e+07 5.2586e+07  43.2%   361  752s
  4913  3367 6.0160e+07  179  112 9.2503e+07 5.2586e+07  43.2%   364  778s
  4954  3528 6.0264e+07  185  136 9.2503e+07 5.2586e+07  43.2%   363  781s
  5347  3858 6.5874e+07  230  107 9.2503e+07 5.2586e+07  43.2%   360  787s
  5880  4262 6.9253e+07  285  128 9.2503e+07 5.2586e+07  43.2%   344  791s
  6559  4682 8.5134e+07  362  166 9.2503e+07 5.2586e+07  43.2%   323  795s
  7260  4923 9.2496e+07  459   52 9.2503e+07 5.2586e+07  43.2%   302  801s
  7455  5064 5.2593e+07   55  486 9.2503e+07 5.2586e+07  43.2%   300  805s
  7849  5288 5.2636e+07   62  407 9.2503e+07 5.2586e+07  43.2%   298  812s
  8084  5216 5.2636e+07   65  436 9.2503e+07 5.2586e+07  43.2%   297  820s
  8297  5587 5.2703e+07   78  322 9.2503e+07 5.2586e+07  43.2%   299  826s
  8539  5600 5.2754e+07   91  230 9.2503e+07 5.2586e+07  43.2%   299  830s
  8680  5701 5.2906e+07  112  318 9.2503e+07 5.2586e+07  43.2%   304  835s
  9080  6135 7.0680e+07  168  339 9.2503e+07 5.2586e+07  43.2%   307  843s
  9379  6787 7.9659e+07  219  154 9.2503e+07 5.2586e+07  43.2%   301  847s
 10134  7253 9.0468e+07  265   87 9.2503e+07 5.2586e+07  43.2%   288  852s
 10888  7518 9.2437e+07  330   34 9.2503e+07 5.2586e+07  43.2%   273  858s
 11501  7935 5.2606e+07   58  499 9.2503e+07 5.2586e+07  43.2%   268  862s
 12170  8102 5.2611e+07   64  438 9.2503e+07 5.2586e+07  43.2%   258  866s
 12518  8627 5.2635e+07   73  348 9.2503e+07 5.2586e+07  43.2%   255  875s
 13067  9381 5.2984e+07  118  272 9.2503e+07 5.2586e+07  43.2%   259  882s
 13895 10111 5.5480e+07  144  394 9.2503e+07 5.2586e+07  43.2%   255  887s
 14648 10530 8.6641e+07  187  132 9.2503e+07 5.2586e+07  43.2%   249  894s
 15094 10991 9.1935e+07  234   53 9.2503e+07 5.2586e+07  43.2%   245  899s
 15623 11640 5.2587e+07   58  636 9.2503e+07 5.2586e+07  43.2%   240  904s
 16085 11640     cutoff  205      9.2503e+07 5.2586e+07  43.2%   236  905s
 16323 11877 5.2589e+07   69  551 9.2503e+07 5.2586e+07  43.2%   236  911s
 16566 12408 5.2593e+07   78  400 9.2503e+07 5.2586e+07  43.2%   236  918s
 17208 12719 5.2621e+07   93  417 9.2503e+07 5.2586e+07  43.2%   232  925s
 17572 12847 5.2790e+07  115  430 9.2503e+07 5.2586e+07  43.2%   233  931s
 17729 13302 5.2939e+07  127  573 9.2503e+07 5.2586e+07  43.2%   233  938s
 18197 14214 7.3574e+07  155  319 9.2503e+07 5.2587e+07  43.2%   233  946s
 19233 14576 5.2626e+07   59  476 9.2503e+07 5.2587e+07  43.2%   226  953s
 19595 14792 5.2651e+07   68  442 9.2503e+07 5.2587e+07  43.2%   228  960s
 19823 15067 5.2653e+07   70  467 9.2503e+07 5.2587e+07  43.2%   227  970s
 20130 15659 5.2658e+07   78  417 9.2503e+07 5.2587e+07  43.2%   226  980s
 20767 15940 5.2811e+07  108  467 9.2503e+07 5.2587e+07  43.2%   226  988s
 21048 16280 5.5870e+07  139  563 9.2503e+07 5.2587e+07  43.2%   227  995s
 21420 16850 8.1789e+07  154  246 9.2503e+07 5.2588e+07  43.1%   228 1003s
 22024 17384 5.2619e+07   65  433 9.2503e+07 5.2588e+07  43.1%   229 1011s
 22585 18265 5.2655e+07   85  365 9.2503e+07 5.2588e+07  43.1%   228 1021s
 23682 18470 5.3991e+07  119  382 9.2503e+07 5.2588e+07  43.1%   226 1028s
 23887 18889 5.9211e+07  150  388 9.2503e+07 5.2589e+07  43.1%   230 1037s
 24334 19514 5.2607e+07   62  596 9.2503e+07 5.2589e+07  43.1%   232 1045s
 24984 20121 5.2696e+07   86  491 9.2503e+07 5.2589e+07  43.1%   233 1055s
 25670 20122 5.2706e+07   93  487 9.2503e+07 5.2589e+07  43.1%   234 1139s
 25672 20123 6.7519e+07  246   47 9.2503e+07 5.2589e+07  43.1%   234 1141s
 25675 20125 5.3301e+07  121  610 9.2503e+07 5.2589e+07  43.1%   234 1146s
 25678 20127 9.2147e+07  364  379 9.2503e+07 5.2589e+07  43.1%   234 1150s
 25683 20131 6.6035e+07  168  466 9.2503e+07 5.2589e+07  43.1%   234 1155s
 25690 20135 7.0255e+07  223  535 9.2503e+07 5.2589e+07  43.1%   234 1160s
 25701 20143 8.5100e+07  162  391 9.2503e+07 5.2589e+07  43.1%   234 1165s
 25707 20147 5.3855e+07  126  472 9.2503e+07 5.2589e+07  43.1%   234 1171s
 25713 20151 5.7073e+07  181  450 9.2503e+07 5.2589e+07  43.1%   234 1177s
 25719 20155 9.2481e+07  270  406 9.2503e+07 5.2589e+07  43.1%   234 1182s
 25724 20158 6.1962e+07  151  504 9.2503e+07 5.2589e+07  43.1%   234 1185s
 25730 20162 5.2968e+07   62  538 9.2503e+07 5.2589e+07  43.1%   234 1190s
 25734 20165 5.2600e+07   64  567 9.2503e+07 5.2589e+07  43.1%   234 1195s
 25739 20168 8.2497e+07  313  641 9.2503e+07 5.2589e+07  43.1%   234 1202s
 25743 20171 9.1945e+07  249  588 9.2503e+07 5.2589e+07  43.1%   234 1206s
 25744 20171 7.8407e+07  170  540 9.2503e+07 5.2589e+07  43.1%   234 1210s
 25753 20177 8.7154e+07  224  673 9.2503e+07 5.2589e+07  43.1%   234 1218s
 25756 20179 7.2861e+07  143  667 9.2503e+07 5.2590e+07  43.1%   234 1220s
 25762 20183 8.1681e+07  151  591 9.2503e+07 5.2590e+07  43.1%   233 1227s
 25770 20189 5.2706e+07   93  545 9.2503e+07 5.2591e+07  43.1%   233 1230s
 25772 20190 6.7519e+07  246  541 9.2503e+07 5.2593e+07  43.1%   233 1235s
 25783 20197 6.6035e+07  168  594 9.2503e+07 5.2594e+07  43.1%   233 1244s
 25785 20199 7.4596e+07  155  543 9.2503e+07 5.2594e+07  43.1%   233 1245s
 25790 20202 7.0255e+07  223  425 9.2503e+07 5.2595e+07  43.1%   233 1251s
 25802 20210 9.2493e+07  264  525 9.2503e+07 5.2596e+07  43.1%   233 1255s
 25810 20215 8.7746e+07  202  471 9.2503e+07 5.2597e+07  43.1%   233 1261s
 25812 20217 8.6085e+07  179  452 9.2503e+07 5.2598e+07  43.1%   233 1265s
 25823 20224 7.1059e+07  144  487 9.2503e+07 5.2599e+07  43.1%   233 1271s
 25835 20232 5.2608e+07   59  550 9.2503e+07 5.2601e+07  43.1%   233 1278s
 25840 20235 6.3587e+07  212  527 9.2503e+07 5.2602e+07  43.1%   233 1280s
 25848 20241 9.2473e+07  258  574 9.2503e+07 5.2603e+07  43.1%   233 1287s
 25855 20245 5.5903e+07  123  373 9.2503e+07 5.2604e+07  43.1%   233 1290s
 25865 20252 5.7936e+07  152  505 9.2503e+07 5.2605e+07  43.1%   233 1296s
 25867 20253 9.2467e+07  247  410 9.2503e+07 5.2606e+07  43.1%   233 1300s
 25876 20259 5.4167e+07  128  465 9.2503e+07 5.2607e+07  43.1%   232 1306s
 25883 20264 6.6035e+07  168  527 9.2503e+07 5.2608e+07  43.1%   232 1311s
 25884 20265 7.8059e+07  146  519 9.2503e+07 5.2608e+07  43.1%   232 1315s
 25890 20269 7.0255e+07  223  462 9.2503e+07 5.2610e+07  43.1%   232 1323s
 25895 20272 6.0670e+07  141  496 9.2503e+07 5.2611e+07  43.1%   232 1326s
 25901 20276 8.5100e+07  162  445 9.2503e+07 5.2612e+07  43.1%   232 1330s
 25906 20279 9.2127e+07  268  415 9.2503e+07 5.2613e+07  43.1%   232 1335s
 25913 20284 5.7073e+07  181  358 9.2503e+07 5.2614e+07  43.1%   232 1341s
 25922 20290 6.0690e+07  143  509 9.2503e+07 5.2615e+07  43.1%   232 1345s
 25932 20297 5.3187e+07  124  497 9.2503e+07 5.2616e+07  43.1%   232 1351s
 25933 20297 5.2681e+07   94  522 9.2503e+07 5.2616e+07  43.1%   232 1355s
 25941 20303 7.1902e+07  148  505 9.2503e+07 5.2617e+07  43.1%   232 1361s
 25950 20309 8.6177e+07  239  522 9.2503e+07 5.2617e+07  43.1%   232 1365s
 25961 20316 8.7863e+07  155  503 9.2503e+07 5.2619e+07  43.1%   232 1371s
 25963 20317 6.5669e+07  141  546 9.2503e+07 5.2619e+07  43.1%   232 1375s
 25970 20322 5.2706e+07   93  428 9.2503e+07 5.2620e+07  43.1%   232 1380s
 25980 20329 6.3583e+07  140  457 9.2503e+07 5.2622e+07  43.1%   232 1387s
 25988 20334 8.9479e+07  178  520 9.2503e+07 5.2623e+07  43.1%   231 1390s
 25995 20339 6.0670e+07  141  620 9.2503e+07 5.2624e+07  43.1%   231 1395s
 25999 20341 8.7815e+07  163  493 9.2503e+07 5.2624e+07  43.1%   231 1400s
 26008 20347 9.2375e+07  215  563 9.2503e+07 5.2627e+07  43.1%   231 1405s
 26014 20351 7.3748e+07  147  589 9.2503e+07 5.2627e+07  43.1%   231 1411s
 26022 20357 6.0690e+07  143  510 9.2503e+07 5.2628e+07  43.1%   231 1416s
 26028 20361 9.2089e+07  280  420 9.2503e+07 5.2630e+07  43.1%   231 1420s
 26031 20363 7.4073e+07  158  502 9.2503e+07 5.2630e+07  43.1%   231 1425s
 26038 20367 6.6123e+07  153  411 9.2503e+07 5.2631e+07  43.1%   231 1430s
 26046 20373 6.9717e+07  157  402 9.2503e+07 5.2631e+07  43.1%   231 1435s
 26053 20377 8.7154e+07  224  374 9.2503e+07 5.2632e+07  43.1%   231 1440s
 26062 20383 8.1681e+07  151  489 9.2503e+07 5.2632e+07  43.1%   231 1446s
 26067 20387 9.2467e+07  247  367 9.2503e+07 5.2633e+07  43.1%   231 1450s
 26073 20391 9.2092e+07  338  347 9.2503e+07 5.2633e+07  43.1%   231 1455s
 26079 20395 8.8641e+07  214  457 9.2503e+07 5.2634e+07  43.1%   231 1460s
 26087 20400 5.2635e+07   66  380 9.2503e+07 5.2635e+07  43.1%   231 1465s
 26091 20403 8.0360e+07  178  428 9.2503e+07 5.2637e+07  43.1%   231 1470s
 26101 20409 8.5100e+07  162  341 9.2503e+07 5.2640e+07  43.1%   230 1475s
 26110 20415 8.7746e+07  202  385 9.2503e+07 5.2642e+07  43.1%   230 1481s
 26120 20422 5.2673e+07   76  444 9.2503e+07 5.2643e+07  43.1%   230 1487s
 26129 20428 8.7572e+07  261  582 9.2503e+07 5.2644e+07  43.1%   230 1490s
 26136 20433 5.2684e+07   82  462 9.2503e+07 5.2645e+07  43.1%   230 1496s
 26137 20433 9.2211e+07  173  473 9.2503e+07 5.2645e+07  43.1%   230 1500s
 26144 20438 7.8407e+07  170  474 9.2503e+07 5.2646e+07  43.1%   230 1505s
H26153 19413                    9.249882e+07 5.2646e+07  43.1%   230 1511s
H26154 18435                    9.249747e+07 5.2646e+07  43.1%   230 1511s
H26164 17511                    9.249717e+07 5.2647e+07  43.1%   230 1515s
H26165 16628                    9.249687e+07 5.2647e+07  43.1%   230 1518s
 26169 16631 9.2483e+07  351  473 9.2497e+07 5.2648e+07  43.1%   230 1520s
H26174 15794                    9.249667e+07 5.2649e+07  43.1%   230 1525s
 26181 15799 8.9603e+07  156  403 9.2497e+07 5.2649e+07  43.1%   230 1530s
 26189 15804 5.5151e+07  127  465 9.2497e+07 5.2650e+07  43.1%   230 1535s
 26199 15811 8.7815e+07  163  556 9.2497e+07 5.2651e+07  43.1%   230 1540s
H26202 15014                    9.249655e+07 5.2652e+07  43.1%   230 1540s
 26211 15020 5.2748e+07  103  446 9.2497e+07 5.2653e+07  43.1%   229 1546s
 26218 15024 5.2682e+07   83  461 9.2497e+07 5.2654e+07  43.1%   229 1551s
 26225 15029 6.0356e+07  139  366 9.2497e+07 5.2655e+07  43.1%   229 1555s
 26232 15034 5.3187e+07  124  411 9.2497e+07 5.2655e+07  43.1%   229 1560s
 26237 15037 9.2211e+07  173  414 9.2497e+07 5.2656e+07  43.1%   229 1565s
 26251 15046 8.7919e+07  185  374 9.2497e+07 5.2656e+07  43.1%   229 1570s
 26258 15051 9.1945e+07  249  418 9.2497e+07 5.2657e+07  43.1%   229 1575s
 26270 15059 5.2706e+07   93  489 9.2497e+07 5.2659e+07  43.1%   229 1580s
 26280 15066 6.3583e+07  140  315 9.2497e+07 5.2660e+07  43.1%   229 1586s
 26288 15071 8.9479e+07  178  409 9.2497e+07 5.2660e+07  43.1%   229 1590s
 26295 15076 6.0670e+07  141  554 9.2497e+07 5.2660e+07  43.1%   229 1595s
 26304 15082 5.3957e+07  133  477 9.2497e+07 5.2661e+07  43.1%   229 1600s
 26313 15088 5.7073e+07  181  521 9.2497e+07 5.2661e+07  43.1%   229 1605s
 26320 15092 5.2673e+07   76  509 9.2497e+07 5.2662e+07  43.1%   229 1611s
 26324 15095 6.1962e+07  151  491 9.2497e+07 5.2662e+07  43.1%   229 1616s
 26330 15099 5.2968e+07   62  493 9.2497e+07 5.2662e+07  43.1%   228 1621s
 26334 15102 5.2664e+07   64  561 9.2497e+07 5.2664e+07  43.1%   228 1625s
 26341 15106 7.1902e+07  148  429 9.2497e+07 5.2664e+07  43.1%   228 1630s
 26349 15112 6.3122e+07  204  469 9.2497e+07 5.2665e+07  43.1%   228 1636s
 26354 15115 5.8679e+07  148  377 9.2497e+07 5.2666e+07  43.1%   228 1641s
 26363 15121 6.5669e+07  141  412 9.2497e+07 5.2666e+07  43.1%   228 1646s
 26367 15124 9.2467e+07  247  278 9.2497e+07 5.2667e+07  43.1%   228 1650s
 26373 15128 9.2092e+07  338  379 9.2497e+07 5.2668e+07  43.1%   228 1655s
 26380 15132 6.3583e+07  140  441 9.2497e+07 5.2669e+07  43.1%   228 1660s
 26385 15136 7.4596e+07  155  399 9.2497e+07 5.2670e+07  43.1%   228 1665s
 26397 15144 8.5214e+07  161  364 9.2497e+07 5.2671e+07  43.1%   228 1672s
 26405 15149 5.2829e+07  100  481 9.2497e+07 5.2673e+07  43.1%   228 1677s
 26414 15155 7.3748e+07  147  531 9.2497e+07 5.2674e+07  43.1%   228 1681s
 26417 15157 5.2675e+07   70  356 9.2497e+07 5.2675e+07  43.1%   228 1685s
 26424 15162 6.1962e+07  151  383 9.2497e+07 5.2675e+07  43.1%   228 1690s
 26429 15165 8.7572e+07  261  409 9.2497e+07 5.2676e+07  43.1%   228 1695s
 26437 15170 9.2211e+07  173  500 9.2497e+07 5.2677e+07  43.0%   228 1701s
 26446 15176 6.9717e+07  157  419 9.2497e+07 5.2678e+07  43.0%   227 1707s
 26454 15182 5.8679e+07  148  521 9.2497e+07 5.2679e+07  43.0%   227 1710s
 26459 15185 6.0253e+07  142  418 9.2497e+07 5.2681e+07  43.0%   227 1715s
 26467 15190 9.2467e+07  247  523 9.2497e+07 5.2683e+07  43.0%   227 1720s
 26475 15196 5.3301e+07  121  466 9.2497e+07 5.2684e+07  43.0%   227 1725s
 26484 15202 7.8059e+07  146  473 9.2497e+07 5.2685e+07  43.0%   227 1730s
 26497 15210 8.5214e+07  161  650 9.2497e+07 5.2686e+07  43.0%   227 1735s
 26506 15216 9.2127e+07  268  584 9.2497e+07 5.2688e+07  43.0%   227 1741s
 26513 15221 5.7073e+07  181  561 9.2497e+07 5.2689e+07  43.0%   227 1745s
 26520 15227 5.2689e+07   76   99 9.2497e+07 5.2689e+07  43.0%   261 1750s
 26524 15230 6.1962e+07  151  402 9.2497e+07 5.2689e+07  43.0%   261 1755s
 26529 15233 8.7572e+07  261  432 9.2497e+07 5.2689e+07  43.0%   261 1760s
 26534 15237 5.2689e+07   64  411 9.2497e+07 5.2689e+07  43.0%   261 1765s
 26540 15241 6.3587e+07  212  526 9.2497e+07 5.2689e+07  43.0%   261 1770s
 26552 15249 5.6808e+07  102  516 9.2497e+07 5.2689e+07  43.0%   261 1775s
 26559 15253 6.0253e+07  142  566 9.2497e+07 5.2690e+07  43.0%   261 1780s
 26564 15257 8.9876e+07  191  460 9.2497e+07 5.2691e+07  43.0%   261 1785s
 26572 15262 6.7519e+07  246  409 9.2497e+07 5.2692e+07  43.0%   261 1791s
 26584 15270 7.8059e+07  146  474 9.2497e+07 5.2693e+07  43.0%   261 1796s
 26588 15273 8.9479e+07  178  467 9.2497e+07 5.2694e+07  43.0%   261 1800s
 26594 15277 7.3945e+07  155  491 9.2497e+07 5.2695e+07  43.0%   261 1806s
 26601 15281 8.5100e+07  162  460 9.2497e+07 5.2696e+07  43.0%   261 1811s
 26609 15287 6.8856e+07  220  534 9.2497e+07 5.2699e+07  43.0%   261 1816s
 26615 15291 5.2743e+07   96  471 9.2497e+07 5.2701e+07  43.0%   260 1821s
 26620 15294 5.2703e+07   76  475 9.2497e+07 5.2703e+07  43.0%   260 1825s
 26627 15299 6.7981e+07  150  318 9.2497e+07 5.2705e+07  43.0%   260 1831s
 26637 15305 9.2211e+07  173  375 9.2497e+07 5.2706e+07  43.0%   260 1835s
 26643 15309 9.1945e+07  249  438 9.2497e+07 5.2707e+07  43.0%   260 1840s
 26654 15317 5.8679e+07  148  465 9.2497e+07 5.2709e+07  43.0%   260 1845s
 26668 15326 5.7696e+07  141  528 9.2497e+07 5.2711e+07  43.0%   260 1851s
 26676 15331 5.4167e+07  128  493 9.2497e+07 5.2712e+07  43.0%   260 1855s
 26684 15337 7.8059e+07  146  390 9.2497e+07 5.2713e+07  43.0%   260 1860s
 26691 15341 8.0360e+07  178  551 9.2497e+07 5.2713e+07  43.0%   260 1865s
 26699 15347 8.7815e+07  163  575 9.2497e+07 5.2714e+07  43.0%   260 1871s
 26705 15351 5.2829e+07  100  509 9.2497e+07 5.2715e+07  43.0%   260 1875s
 26714 15357 7.3748e+07  147  441 9.2497e+07 5.2717e+07  43.0%   260 1881s
 26722 15362 6.0690e+07  143  461 9.2497e+07 5.2718e+07  43.0%   259 1885s
H26728 14594                    9.249614e+07 5.2718e+07  43.0%   259 1889s
 26731 14596 7.4073e+07  158  449 9.2496e+07 5.2718e+07  43.0%   259 1890s
 26740 14602 6.3587e+07  212  485 9.2496e+07 5.2720e+07  43.0%   259 1895s
 26748 14607 9.2473e+07  258  487 9.2496e+07 5.2721e+07  43.0%   259 1901s
 26754 14611 5.8679e+07  148  509 9.2496e+07 5.2722e+07  43.0%   259 1905s
 26766 14619 7.3600e+07  152  581 9.2496e+07 5.2724e+07  43.0%   259 1910s
 26777 14627 5.2732e+07  100  560 9.2496e+07 5.2725e+07  43.0%   259 1916s
H26777 13891                    9.249610e+07 5.2725e+07  43.0%   259 1918s
 26784 13895 7.8059e+07  146  582 9.2496e+07 5.2726e+07  43.0%   259 1920s
 26796 13903 5.9038e+07  198  593 9.2496e+07 5.2728e+07  43.0%   259 1925s
H26803 13208                    9.249607e+07 5.2729e+07  43.0%   259 1931s
 26812 13214 8.6085e+07  179  497 9.2496e+07 5.2731e+07  43.0%   259 1937s
 26817 13217 5.2732e+07   70  410 9.2496e+07 5.2732e+07  43.0%   259 1941s
 26827 13224 6.7981e+07  150  530 9.2496e+07 5.2735e+07  43.0%   258 1946s
 26839 13232 8.2497e+07  313  573 9.2496e+07 5.2738e+07  43.0%   258 1950s
 26845 13236 9.2214e+07  195  594 9.2496e+07 5.2739e+07  43.0%   258 1956s
 26851 13240 8.7919e+07  185  481 9.2496e+07 5.2740e+07  43.0%   258 1960s
 26859 13245 6.0253e+07  142  428 9.2496e+07 5.2741e+07  43.0%   258 1965s
 26872 13254 6.7519e+07  246  501 9.2496e+07 5.2743e+07  43.0%   258 1971s
 26880 13259 6.3583e+07  140  569 9.2496e+07 5.2744e+07  43.0%   258 1975s
 26887 13264 5.2744e+07   66  463 9.2496e+07 5.2744e+07  43.0%   258 1981s
 26892 13267 5.7696e+07  141  459 9.2496e+07 5.2746e+07  43.0%   258 1985s
 26904 13275 5.3957e+07  133  431 9.2496e+07 5.2749e+07  43.0%   258 1990s
 26912 13281 8.6085e+07  179  472 9.2496e+07 5.2750e+07  43.0%   258 1995s
 26920 13286 5.2752e+07   76  491 9.2496e+07 5.2752e+07  43.0%   258 2000s
 26927 13291 6.7981e+07  150  427 9.2496e+07 5.2753e+07  43.0%   257 2005s
 26937 13297 9.2211e+07  173  429 9.2496e+07 5.2754e+07  43.0%   257 2010s
 26944 13302 7.8407e+07  170  470 9.2496e+07 5.2756e+07  43.0%   257 2015s
 26952 13307 5.6808e+07  102  529 9.2496e+07 5.2757e+07  43.0%   257 2020s
 26959 13312 6.0253e+07  142  466 9.2496e+07 5.2758e+07  43.0%   257 2025s
 26964 13315 8.9876e+07  191  452 9.2496e+07 5.2758e+07  43.0%   257 2030s
 26972 13321 6.7519e+07  246  455 9.2496e+07 5.2759e+07  43.0%   257 2035s
 26980 13326 6.3583e+07  140  512 9.2496e+07 5.2759e+07  43.0%   257 2040s
 26991 13333 8.0360e+07  178  549 9.2496e+07 5.2760e+07  43.0%   257 2045s
 26997 13337 8.5214e+07  161  492 9.2496e+07 5.2761e+07  43.0%   257 2050s
 27008 13345 9.2375e+07  215  458 9.2496e+07 5.2762e+07  43.0%   257 2055s
 27012 13347 8.6085e+07  179  588 9.2496e+07 5.2762e+07  43.0%   257 2060s
 27020 13353 5.2763e+07   76  620 9.2496e+07 5.2763e+07  43.0%   257 2065s
 27026 13357 5.2949e+07  116  555 9.2496e+07 5.2763e+07  43.0%   257 2070s
 27031 13360 7.4073e+07  158  546 9.2496e+07 5.2763e+07  43.0%   256 2075s
 27038 13365 6.6123e+07  153  437 9.2496e+07 5.2763e+07  43.0%   256 2080s
 27046 13370 6.9717e+07  157  485 9.2496e+07 5.2764e+07  43.0%   256 2085s
 27052 13374 5.6808e+07  102  444 9.2496e+07 5.2764e+07  43.0%   256 2090s
 27060 13379 6.1680e+07  188  496 9.2496e+07 5.2765e+07  43.0%   256 2095s
 27068 13385 5.7696e+07  141  529 9.2496e+07 5.2765e+07  43.0%   256 2100s
 27074 13389 7.1497e+07  147  571 9.2496e+07 5.2765e+07  43.0%   256 2105s
 27079 13392 8.8641e+07  214  652 9.2496e+07 5.2765e+07  43.0%   256 2110s
 27084 13395 7.8059e+07  146  610 9.2496e+07 5.2765e+07  43.0%   256 2117s
 27088 13398 8.9479e+07  178  540 9.2496e+07 5.2766e+07  43.0%   256 2122s
 27093 13401 5.2766e+07   69  565 9.2496e+07 5.2766e+07  43.0%   256 2125s
 27099 13405 8.7815e+07  163  640 9.2496e+07 5.2767e+07  43.0%   256 2130s
 27103 13408 8.3823e+07  223  635 9.2496e+07 5.2767e+07  43.0%   256 2135s
 27109 13412 6.8856e+07  220  711 9.2496e+07 5.2767e+07  43.0%   256 2140s
 27114 13415 7.3748e+07  147  755 9.2496e+07 5.2767e+07  43.0%   256 2146s
 27117 13417 5.2767e+07   70  622 9.2496e+07 5.2767e+07  43.0%   256 2150s
 27125 13423 6.0356e+07  139  625 9.2496e+07 5.2768e+07  43.0%   256 2155s
 27129 13425 8.7572e+07  261  621 9.2496e+07 5.2768e+07  43.0%   256 2161s
 27132 13427 5.3187e+07  124  616 9.2496e+07 5.2768e+07  43.0%   256 2165s
 27136 13430 5.2768e+07   82  537 9.2496e+07 5.2768e+07  43.0%   255 2170s
 27143 13435 9.1945e+07  249  582 9.2496e+07 5.2768e+07  43.0%   255 2175s
 27147 13437 7.4516e+07  158  590 9.2496e+07 5.2768e+07  43.0%   255 2180s
 27152 13441 5.6808e+07  102  502 9.2496e+07 5.2769e+07  42.9%   255 2187s
 27160 13446 6.1680e+07  188  567 9.2496e+07 5.2770e+07  42.9%   255 2191s
 27165 13449 5.7936e+07  152  601 9.2496e+07 5.2770e+07  42.9%   255 2196s
 27172 13454 6.7519e+07  246  625 9.2496e+07 5.2771e+07  42.9%   255 2200s
 27176 13457 5.4167e+07  128  701 9.2496e+07 5.2771e+07  42.9%   255 2205s
 27185 13463 7.4596e+07  155  623 9.2496e+07 5.2771e+07  42.9%   255 2210s
 27189 13465 5.5151e+07  127  635 9.2496e+07 5.2772e+07  42.9%   255 2216s
 27194 13469 7.3945e+07  155  524 9.2496e+07 5.2772e+07  42.9%   255 2221s
 27201 13473 8.5100e+07  162  471 9.2496e+07 5.2772e+07  42.9%   255 2226s
 27207 13477 5.3855e+07  126  541 9.2496e+07 5.2773e+07  42.9%   255 2230s
 27214 13483 7.3748e+07  147  319 9.2496e+07 5.2773e+07  42.9%   285 2235s
 27220 13487 5.2773e+07   76  249 9.2496e+07 5.2773e+07  42.9%   285 2240s
 27225 13491 6.0356e+07  139  361 9.2496e+07 5.2773e+07  42.9%   285 2245s
 27230 13494 5.2968e+07   62  599 9.2496e+07 5.2773e+07  42.9%   285 2250s
 27242 13502 8.2720e+07  160  520 9.2496e+07 5.2775e+07  42.9%   285 2257s
 27246 13505 6.9717e+07  157  422 9.2496e+07 5.2776e+07  42.9%   285 2261s
 27251 13508 8.7919e+07  185  423 9.2496e+07 5.2777e+07  42.9%   285 2265s
 27256 13511 7.2861e+07  143  455 9.2496e+07 5.2778e+07  42.9%   285 2270s
 27265 13517 5.7936e+07  152  599 9.2496e+07 5.2779e+07  42.9%   285 2275s
 27272 13522 6.7519e+07  246  626 9.2496e+07 5.2779e+07  42.9%   285 2281s
 27278 13526 9.2147e+07  364  601 9.2496e+07 5.2781e+07  42.9%   284 2285s
 27285 13531 7.4596e+07  155  590 9.2496e+07 5.2781e+07  42.9%   284 2290s
 27291 13535 8.0360e+07  178  546 9.2496e+07 5.2782e+07  42.9%   284 2295s
 27296 13538 5.9038e+07  198  539 9.2496e+07 5.2783e+07  42.9%   284 2302s
 27303 13543 8.3823e+07  223  504 9.2496e+07 5.2783e+07  42.9%   284 2306s
 27307 13545 5.3855e+07  126  507 9.2496e+07 5.2784e+07  42.9%   284 2310s
 27316 13551 6.8770e+07  149  567 9.2496e+07 5.2784e+07  42.9%   284 2316s
 27323 13556 7.1059e+07  144  505 9.2496e+07 5.2785e+07  42.9%   284 2321s
 27329 13560 8.7572e+07  261  467 9.2496e+07 5.2786e+07  42.9%   284 2326s
 27336 13565 5.2787e+07   82  474 9.2496e+07 5.2787e+07  42.9%   284 2330s
 27346 13571 6.9717e+07  157  526 9.2496e+07 5.2787e+07  42.9%   284 2336s
 27354 13577 5.8679e+07  148  498 9.2496e+07 5.2788e+07  42.9%   284 2341s
 27361 13581 8.7863e+07  155  517 9.2496e+07 5.2788e+07  42.9%   284 2345s
 27368 13586 5.7696e+07  141  486 9.2496e+07 5.2789e+07  42.9%   284 2350s
 27376 13591 5.4167e+07  128  589 9.2496e+07 5.2789e+07  42.9%   283 2355s
 27386 13598 6.5542e+07  142  542 9.2496e+07 5.2790e+07  42.9%   283 2360s
 27392 13602 5.7696e+07  141  583 9.2496e+07 5.2790e+07  42.9%   283 2365s
 27398 13606 6.8790e+07  149  553 9.2496e+07 5.2791e+07  42.9%   283 2370s
 27404 13610 5.3957e+07  133  493 9.2496e+07 5.2791e+07  42.9%   283 2375s
 27414 13617 7.3748e+07  147  555 9.2496e+07 5.2792e+07  42.9%   283 2380s
 27422 13622 6.0690e+07  143  511 9.2496e+07 5.2792e+07  42.9%   283 2386s
 27429 13627 8.7572e+07  261  549 9.2496e+07 5.2793e+07  42.9%   283 2390s
 27437 13632 9.2211e+07  173  593 9.2496e+07 5.2793e+07  42.9%   283 2395s

Cutting planes:
  Cover: 7
  Implied bound: 18
  Projected implied bound: 10
  MIR: 239
  Flow cover: 836
  Zero half: 2
  RLT: 6
  Relax-and-lift: 18

Explored 27440 nodes (8476685 simplex iterations) in 2400.07 seconds
Thread count was 12 (of 12 available processors)

Solution count 10: 9.24961e+07 9.24961e+07 9.24961e+07 ... 9.25033e+07

Time limit reached
Best objective 9.249607473639e+07, best bound 5.279335646375e+07, gap 42.9237%
```

Out[15]: 92496074.73639414

In [16]:
```python
print("The minimum max distance is found using a budget of", m1.objval)
```

```
The minimum max distance is found using a budget of 92496074.73639414
```

The minimum max distance is found using a budget of $92,496,074.74

In [17]:
```python
num_sites = 0
utilized = []
for j in sites:
    if (S[j].x + M[j].x + L[j].x) > 0:
        num_sites += 1
        utilized.append(j)
print(num_sites)
```

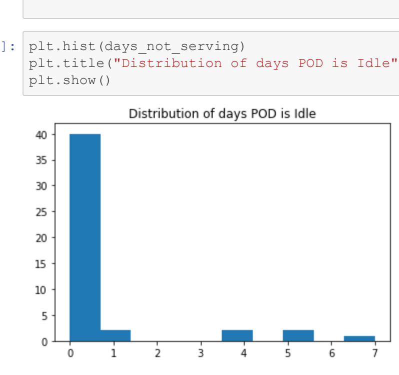
```
7
```

In [18]:
```python
for j in sites:
    print("Site:", j+1, '\t', L[j].x, '\t', S[j].x + M[j].x + L[j].x)
```

```
Site: 1 	 1.0 	 1.0
Site: 2 	 -0.0 	 -0.0
Site: 3 	 0.0 	 0.0
Site: 4 	 -0.0 	 -0.0
Site: 5 	 -0.0 	 -0.0
Site: 6 	 1.0 	 1.0
Site: 7 	 -0.0 	 -0.0
Site: 8 	 -0.0 	 -0.0
Site: 9 	 -0.0 	 -0.0
Site: 10 	 -0.0 	 -0.0
Site: 11 	 1.0 	 1.0
Site: 12 	 -0.0 	 -0.0
Site: 13 	 -0.0 	 -0.0
Site: 14 	 -0.0 	 -0.0
Site: 15 	 1.0 	 1.0
Site: 16 	 -0.0 	 -0.0
Site: 17 	 1.0 	 1.0
Site: 18 	 -0.0 	 -0.0
Site: 19 	 -0.0 	 -0.0
Site: 20 	 1.0 	 1.0
Site: 21 	 -0.0 	 -0.0
Site: 22 	 1.0 	 1.0
Site: 23 	 -0.0 	 -0.0
Site: 24 	 -0.0 	 -0.0
Site: 25 	 -0.0 	 -0.0
Site: 26 	 -0.0 	 -0.0
Site: 27 	 -0.0 	 -0.0
Site: 28 	 -0.0 	 -0.0
Site: 29 	 -0.0 	 0.0
Site: 30 	 -0.0 	 -0.0
Site: 31 	 -0.0 	 -0.0
Site: 32 	 -0.0 	 -0.0
Site: 33 	 -0.0 	 -0.0
Site: 34 	 -0.0 	 -0.0
Site: 35 	 -0.0 	 -0.0
Site: 36 	 -0.0 	 -0.0
Site: 37 	 -0.0 	 -0.0
Site: 38 	 -0.0 	 -0.0
Site: 39 	 -0.0 	 -0.0
Site: 40 	 -0.0 	 -0.0
Site: 41 	 -0.0 	 -0.0
Site: 42 	 -0.0 	 -0.0
Site: 43 	 -0.0 	 -0.0
Site: 44 	 -0.0 	 -0.0
Site: 45 	 -0.0 	 -0.0
Site: 46 	 -0.0 	 -0.0
Site: 47 	 -0.0 	 -0.0
```

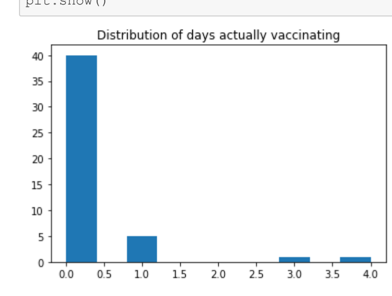
In [19]:
```python
max_ts = []
for j in sites:
    max_t = 0
    for t in days:
        if np.allclose(I[j,t].x,0):
            max_t = t + 1
            max_ts.append(max_t)
            break
```

In [20]:
```python
plt.hist(max_ts)
plt.title("The Distribution of the Number of days to administer vaccine ")
plt.show()
```

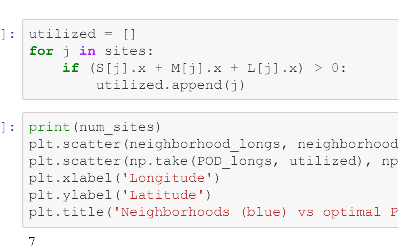


In [21]:
```python
days_not_serving = []
days_serving = []
for j in sites:
    num_days = 0
    serve = 0
    for t in days:
        if np.allclose(X[j,t].x, 0) and np.allclose(I[j,t].x, 0) is False:
            num_days += 1
        if np.allclose(X[j,t].x, 0) is False:
            serve +=1
    days_not_serving.append(num_days)
    days_serving.append(serve)
```

In [22]:
```python
plt.hist(days_not_serving)
plt.title("Distribution of days POD is Idle")
plt.show()
```



In [23]:
```python
plt.hist(days_serving)
plt.title("Distribution of days actually vaccinating")
plt.show()
```

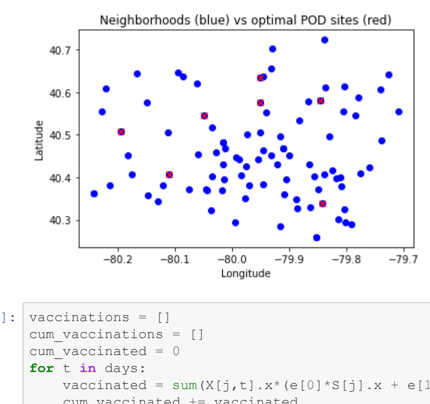


In [24]:
```python
utilized = []
for j in sites:
    if (S[j].x + M[j].x + L[j].x) > 0:
        utilized.append(j)
```

In [25]:
```python
print(num_sites)
plt.scatter(neighborhood_longs, neighborhood_lats, marker='o', c = 'blue')
plt.scatter(np.take(POD_longs, utilized), np.take(POD_lats, utilized), marker='x', c = 'red')
plt.xlabel('Longitude')
plt.ylabel('Latitude')
plt.title('Neighborhoods (blue) vs optimal POD sites (red)')
```

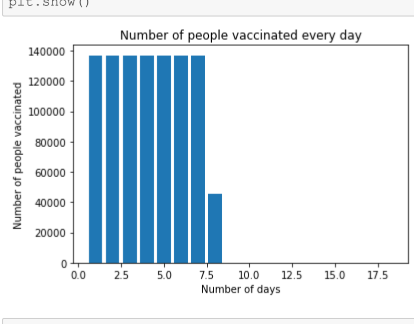
```
7
```

Out[25]: Text(0.5, 1.0, 'Neighborhoods (blue) vs optimal POD sites (red)')

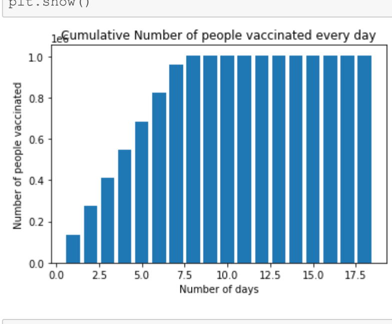


In [26]:
```python
vaccinations = []
cum_vaccinations = []
cum_vaccinated = 0
for t in days:
    vaccinated = sum(X[j,t].x*(e[0]*S[j].x + e[1]*M[j].x + e[2]*L[j].x) for j in sites)
    cum_vaccinated += vaccinated
    vaccinations.append(vaccinated)
    cum_vaccinations.append(cum_vaccinated)
```

In [27]:
```python
timeline = np.arange(100)+1
plt.bar(timeline[:18], vaccinations[:18])
plt.ylabel("Number of people vaccinated")
plt.xlabel("Number of days")
plt.title("Number of people vaccinated every day")
plt.show()
```



In [28]:
```python
timeline = np.arange(100)+1
plt.bar(timeline[:18], cum_vaccinations[:18])
plt.ylabel("Number of people vaccinated")
plt.xlabel("Number of days")
plt.title("Cumulative Number of people vaccinated every day")
plt.show()
```



In [29]:
```python
vaccinations
```

Out[29]:
```
[137000.0,
 137000.0,
 137000.0,
 137000.0,
 137000.0,
 136998.0,
 136941.0,
 45716.0,
 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]
```

In [30]:
```python
for j in sites:
    print("Site:", j+1, '\t', sum(A[i,j].x*p[i] for i in zipcodes))
```

```
Site: 1         23060.0
Site: 2         0.0
Site: 3         0.0
Site: 4         0.0
Site: 5         0.0
Site: 6         351582.0
Site: 7         0.0
Site: 8         0.0
Site: 9         0.0
Site: 10        0.0
Site: 11        136999.0
Site: 12        0.0
Site: 13        0.0
Site: 14        0.0
Site: 15        37210.0
Site: 16        0.0
Site: 17        45716.0
Site: 18        0.0
Site: 19        0.0
Site: 20        310300.0
Site: 21        0.0
Site: 22        99788.0
Site: 23        0.0
Site: 24        0.0
Site: 25        0.0
Site: 26        0.0
Site: 27        0.0
Site: 28        0.0
Site: 29        0.0
Site: 30        0.0
Site: 31        0.0
Site: 32        0.0
Site: 33        0.0
Site: 34        0.0
Site: 35        0.0
Site: 36        0.0
Site: 37        0.0
Site: 38        0.0
Site: 39        0.0
Site: 40        0.0
Site: 41        0.0
Site: 42        0.0
Site: 43        0.0
Site: 44        0.0
Site: 45        0.0
Site: 46        0.0
Site: 47        0.0
```

In [31]:
```python
j = 32
for t in days:
    print(I[j,t].x, '\t', '\t', X[j,t].x)
```

```
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
0.0             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             0.0
```

In [32]:
```python
# Writing to a csv file

with open('Aij_Ben_max_distance.csv', 'w') as f:
    for i in zipcodes:
        for j in sites:
            f.write(str(A[i,j].x) + ',')
        f.write('\n')
print('Done')

with open('Dij_Ben_max_distance.csv', 'w') as f:
    for i in zipcodes:
        for j in sites:
            f.write(str(D[i,j]) + ',')
        f.write('\n')
print('Done')
```

```
Done
Done
```