In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import statsmodels.api as sm
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
from datetime import datetime, timedelta
from statsmodels.tsa.arima.model import ARIMA
import warnings
warnings.filterwarnings('ignore')
```

In [2]:
```
# Loading the data and first look at the data
pharma_data = pd.read_csv('PharmaDrugSales_1.csv')
pharma_data.head()
```

Out[2]:

	Month	Sales
0	7/1/1991	3.526591
1	8/1/1991	3.180891
2	9/1/1991	3.252221
3	10/1/1991	3.611003
4	11/1/1991	3.565869

In [3]:
```
pharma_data.dtypes
```

Out[3]:
```
Month     object
Sales    float64
dtype: object
```

In [4]:
```
def convert_to_datetime(date_str):
    return pd.to_datetime(date_str, format='%m/%d/%Y')
```

In [5]:
```
pharma_data['Month'] = pharma_data['Month'].apply(convert_to_datetime)
pharma_data.dtypes
```

Out[5]:
```
Month    datetime64[ns]
Sales           float64
dtype: object
```

In [6]:
```
pharma_data.head()
```

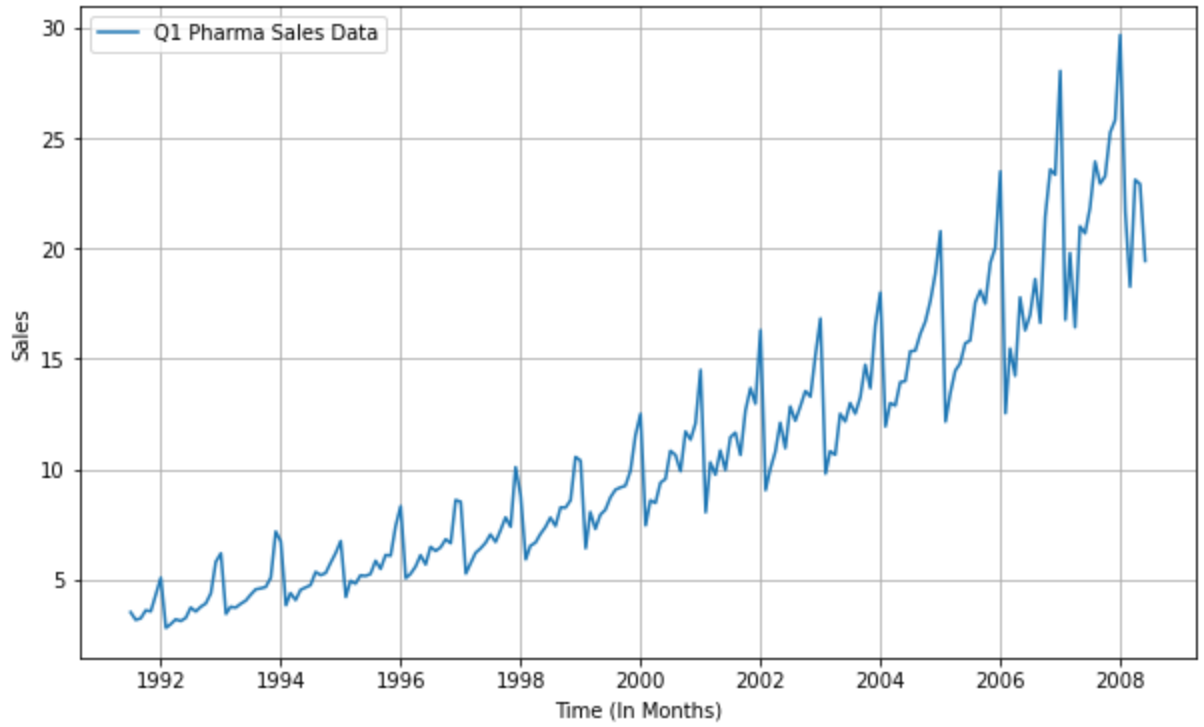
Out[6]:

	Month	Sales
0	1991-07-01	3.526591
1	1991-08-01	3.180891
2	1991-09-01	3.252221
3	1991-10-01	3.611003
4	1991-11-01	3.565869

Question 1

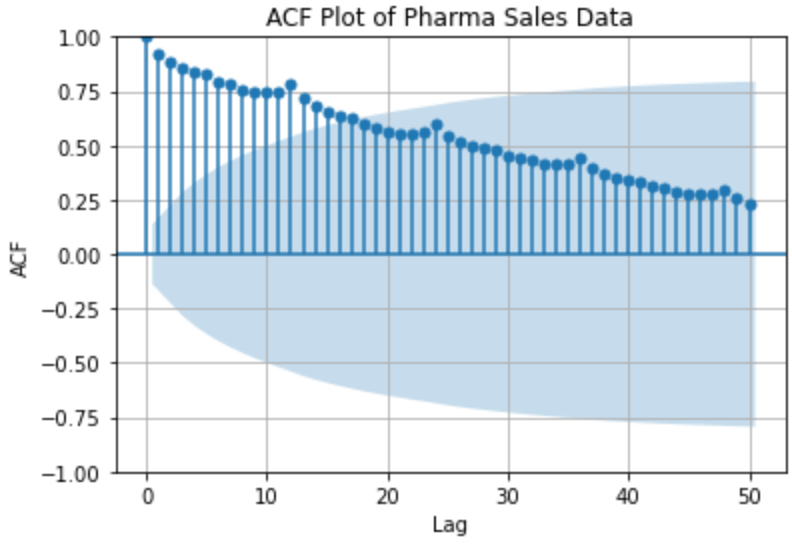
1)

In [7]:
```
# PART 1:
# Plotting the original time series data of sales
plt.figure(figsize=(10,6))
plt.plot(pharma_data['Month'], pharma_data['Sales'], label='Q1 Pharma Sales Data')
plt.xlabel('Time (In Months)')
plt.ylabel('Sales')
plt.legend()
plt.grid(True)
plt.show()
```



2)

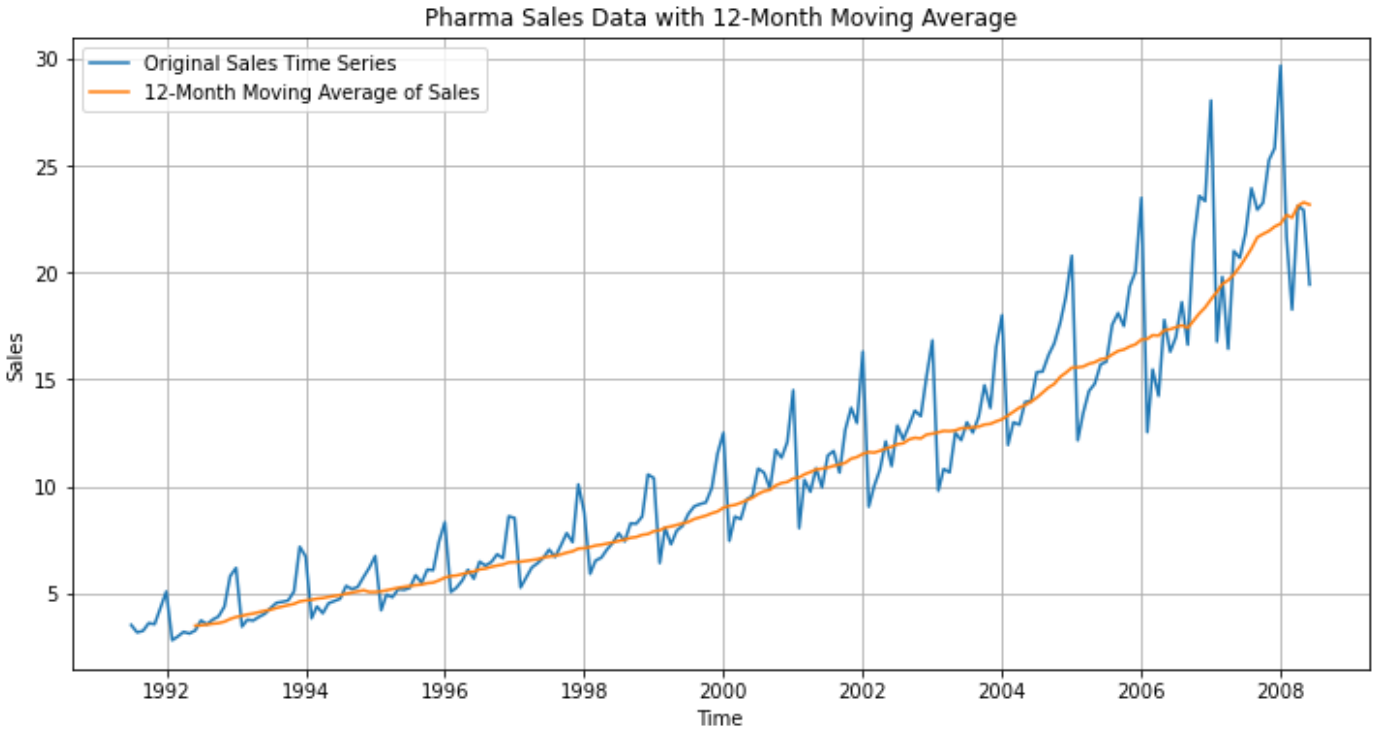
In [8]:
```
# PART 2:
# Plotting the ACF and finding the seasonal period from the plot
plot_acf(pharma_data['Sales'], lags=50)
plt.title('ACF Plot of Pharma Sales Data')
plt.xlabel('Lag')
plt.ylabel('ACF')
plt.grid(True)
plt.show()
```



We can see from the ACF plot that the ACF is slowly decaying and much of the lags are significant which confirms that the time series of we're working with is non-stationary. This can also be seen from the plot of the data, there is a clear trend and seasonal component to it so Sales data is non-stationary. From the ACF plot, the seasonality seems to be annual, so, seasonal period = 12 months.

3)

In [9]:
```
# PART 3:
# Computing moving average of the data to determine the trend and overlaying with origin
window_len = 12

# Calculating 12 month moving average using rolling mean
pharma_data['Moving Average'] = pharma_data['Sales'].rolling(window=window_len).mean()

# Plotting the original sales data and the 12-month moving average data
plt.figure(figsize=(12,6))
plt.plot(pharma_data['Month'], pharma_data['Sales'], label='Original Sales Time Series')
plt.plot(pharma_data['Month'], pharma_data['Moving Average'], label=f'12-Month Moving Av
plt.xlabel('Time')
plt.ylabel('Sales')
plt.title('Pharma Sales Data with 12-Month Moving Average')
plt.legend()
plt.grid(True)
plt.show()
```



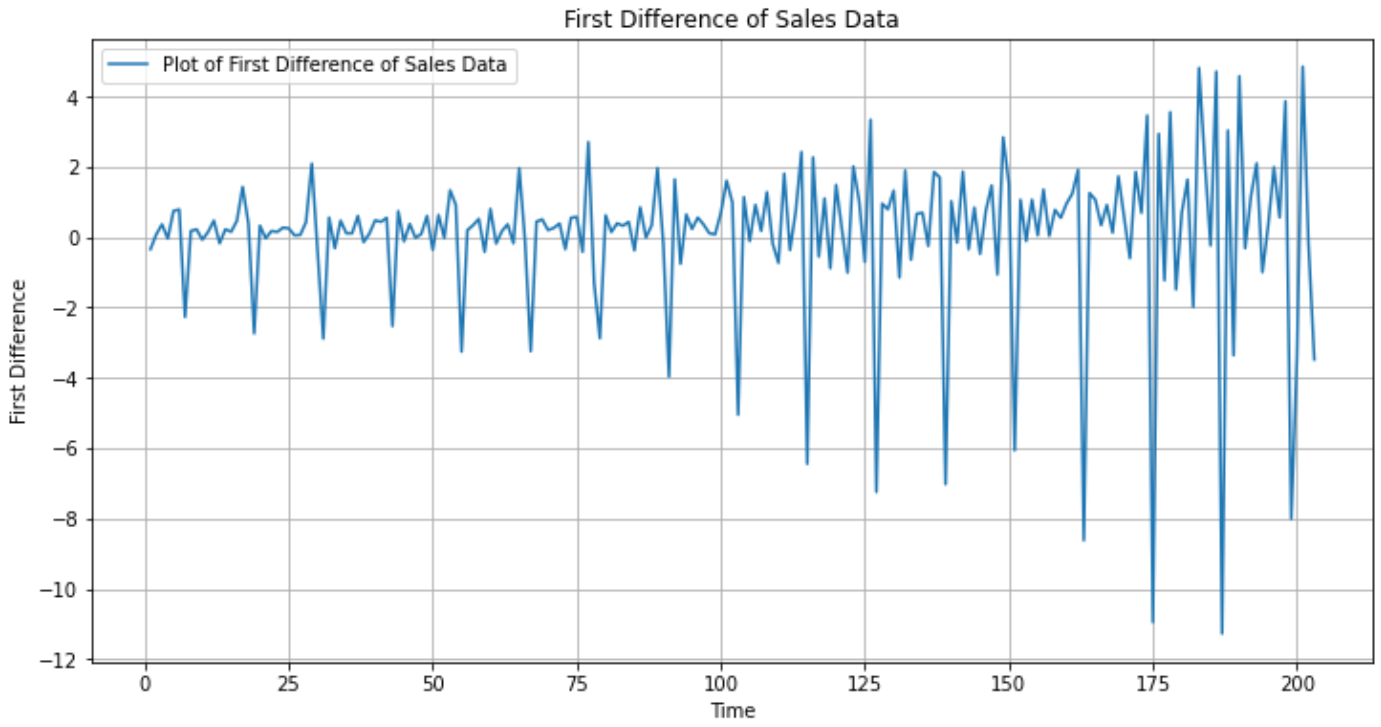
4)

From observing the moving average plot above we can say that the trend seems to be increasing.

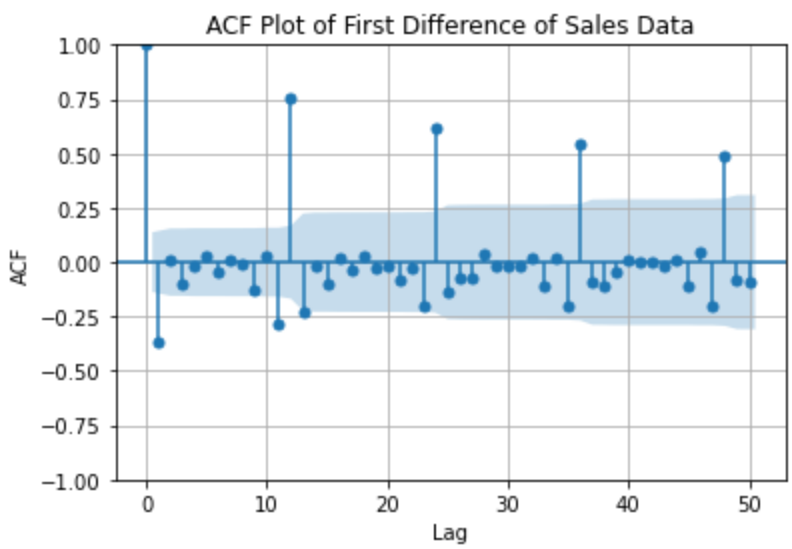
5A)

In [10]:
```
# PART 5 A:
```

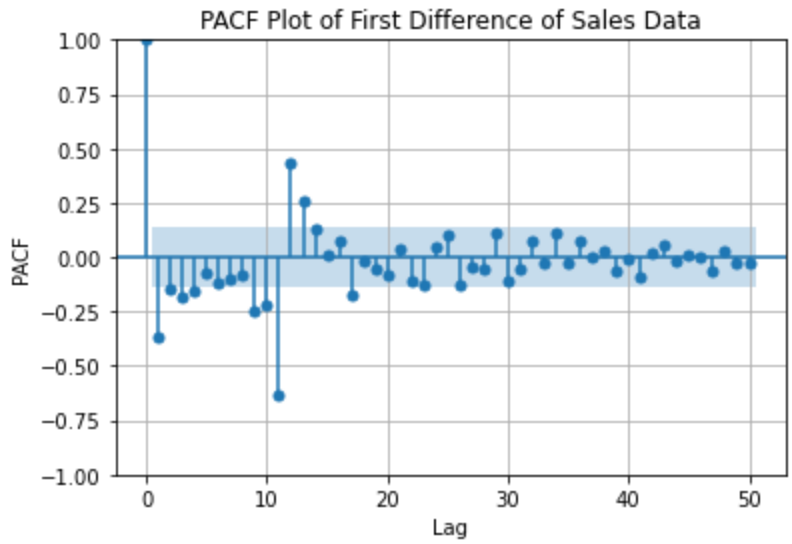
```
# Computing the first difference of the data and plotting the ACF and PACF of the differ
differenced_data = pharma_data['Sales'].diff(1).dropna()

# Plotting the First Difference of Sales Data for visual inspection of data
plt.figure(figsize=(12,6))
plt.plot(differenced_data, label='Plot of First Difference of Sales Data')
plt.xlabel('Time')
plt.ylabel('First Difference')
plt.title('First Difference of Sales Data')
plt.legend()
plt.grid(True)
plt.show()
```



In [11]:
```
# Plotting the ACF and PACF of the First Differenced Data

# ACF
plot_acf(differenced_data, lags=50, alpha=0.05)
plt.title('ACF Plot of First Difference of Sales Data')
plt.xlabel('Lag')
plt.ylabel('ACF')
plt.grid(True)
plt.show()

#PACF
plt.figure(figsize=(10,6))
plot_pacf(differenced_data, lags=50, method='ywm')
plt.title('PACF Plot of First Difference of Sales Data')
plt.xlabel('Lag')
plt.ylabel('PACF')
plt.grid(True)
plt.show()
```




```
<Figure size 720x432 with 0 Axes>
```



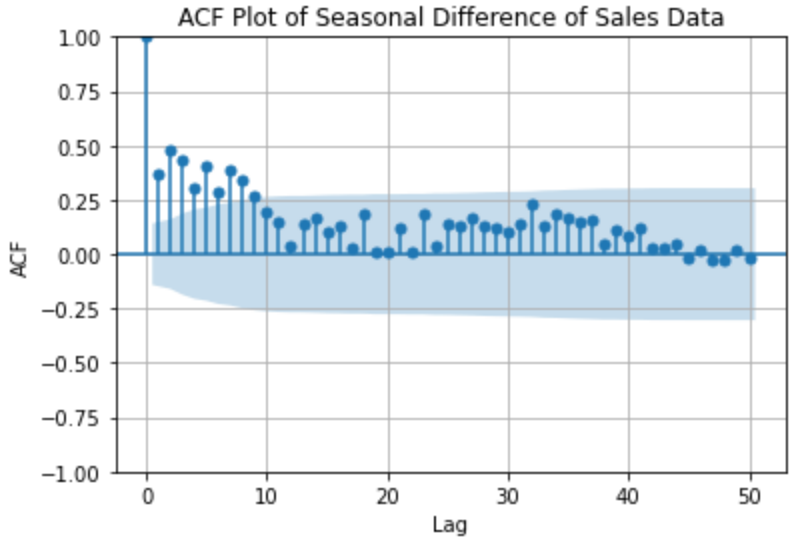
5B)

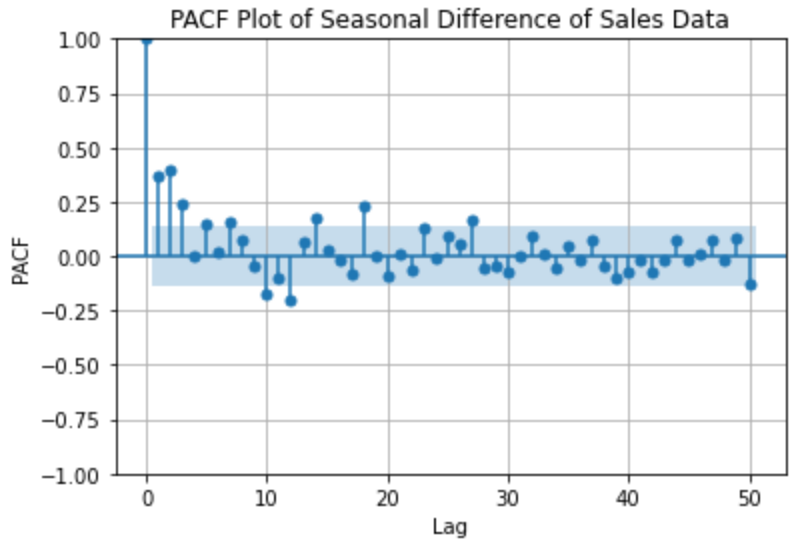
In Q2 the ACF plot is slowly decaying and is significant at many lags which is a sign of the non-stationarity of the data, suggesting underlying trend or seasonality which can be seen to be present from the time series plot of the data. When we apply differencing on the data and plot it, we can see that the mean and variance seem to be constant, the differencing process helps remove the trend and seasonality. The ACF and PACF plots of the first difference of the sales data follow of decaying sinusoidal pattern which indicates the presence of seasonality and from the ACF plot we can make the seasonality to be annual i.e. seasonality period = 12 months. So after applying the first difference we removed the trend in the data but seasonality is still present.

6)

In [12]:
```
# PART 6:
# Performing seasonal differencing
seasonal_differenced_data = pharma_data['Sales'].diff(12).dropna()

# ACF of seasonal differenced sales
plot_acf(seasonal_differenced_data, lags=50, alpha=0.05)
plt.title('ACF Plot of Seasonal Difference of Sales Data')
plt.xlabel('Lag')
```

```
plt.ylabel('ACF')
plt.grid(True)
plt.show()

# PACF
plot_pacf(seasonal_differenced_data, lags=50, method='ywm')
plt.title('PACF Plot of Seasonal Difference of Sales Data')
plt.xlabel('Lag')
plt.ylabel('PACF')
plt.grid(True)
plt.show()
```





In [13]:
```
# TESTING CELL TO LOOK AT THE INDEX OF 2005-06-01 ROW
# Filtering the DataFrame for rows where 'Month' is '2005-06-01'
desired_row = pharma_data[pharma_data['Month'] == '2005-06-01']
index_of_desired_row = desired_row.index[0]
print(index_of_desired_row)
```

```
167
```

7)

In [14]:
```
# PART 7:
# Finding the Best SARIMA Model
# Specifying range of p, d and q
p_vals = range(4)
d = 1
q_vals = range(4)
```

```python
P_VALUES = range(4)
D = 1
Q_VALUES = range(4)
s = 12 # Seasonal period

best_aic = np.inf
best_params = None

trainset = pharma_data[0 : 168] # Data until June 2005 as we found June 2005 index to be

# Grid search to find the best SARIMA model
for p in p_vals:
    for q in q_vals:
        for P in P_VALUES:
            for Q in Q_VALUES:

                try:
                    model = sm.tsa.SARIMAX(trainset['Sales'],
                                           order=(p, d, q),
                                           seasonal_order=(P, D, Q, s),
                                           enforce_stationarity=False,
                                           enforce_invertibility=False)

                    results = model.fit()
                    aic = results.aic
                    print(aic)
                    if aic < best_aic:
                        best_aic = aic
                        best_params = (p, d, q, P, D, Q)
                except:
                    continue

# Fitting the best SARIMA model with the identified parameters
best_model = sm.tsa.SARIMAX(pharma_data['Sales'][ : 168],  # Data until June 2005
                            order=(best_params[0], best_params[1], best_params[2]),
                            seasonal_order=(best_params[3], best_params[4], best_params[
                            enforce_stationarity=False,
                            enforce_invertibility=False)
best_results = best_model.fit()

# Displaying the best model parameters and summary
print(f"Best SARIMA Model: SARIMA{best_params} (seasonal period = 12)")
print(best_results.summary())
```

```
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            1     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  1.05590D+00    |proj g|=  1.13418D-01

At iterate    5    f=  1.05413D+00    |proj g|=  4.79039D-07

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value
```

```
           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    1      5      7      1     0     0   4.790D-07   1.054D+00
  F =   1.0541290038753439

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
 This problem is unconstrained.
 This problem is unconstrained.
 This problem is unconstrained.
356.18734530211555
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            2     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  9.88064D-01    |proj g|=  1.27866D-01

At iterate    5    f=  9.83434D-01    |proj g|=  1.57418D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    2      6      9      1     0     0   2.114D-06   9.834D-01
  F =  0.98343387036150409

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
334.4337804414654
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            3     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  9.54113D-01    |proj g|=  2.20200D-01

At iterate    5    f=  9.06965D-01    |proj g|=  3.02160D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value
```

```
           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    3      8     11      1     0     0   2.150D-06   9.070D-01
  F =  0.90695623707146211

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
310.73729565601127
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  9.89548D-01    |proj g|=  2.81533D-01

At iterate    5    f=  8.57266D-01    |proj g|=  7.37987D-02
 This problem is unconstrained.
At iterate   10    f=  8.41735D-01    |proj g|=  5.62546D-03

At iterate   15    f=  8.41721D-01    |proj g|=  2.78529D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4     16     18      1     0     0   2.193D-06   8.417D-01
  F =  0.84172134761467476

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
290.81837279853073
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            2     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  9.96804D-01    |proj g|=  1.35725D-05
 This problem is unconstrained.

 Warning:  more than 10 function and gradient
   evaluations in the last line search.  Termination
   may possibly be caused by a bad search direction.
 This problem is unconstrained.
 This problem is unconstrained.
           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
```

```
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    2      1     13      1     0     0   1.448D-05   9.968D-01
  F =  0.99680398705586859

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
338.92613965077186
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            3     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  9.89721D-01    |proj g|=  1.24227D-01

At iterate    5    f=  9.80468D-01    |proj g|=  8.05536D-02

At iterate   10    f=  9.78750D-01    |proj g|=  2.02227D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    3     10     13      1     0     0   2.022D-06   9.788D-01
  F =  0.97875006917479634

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
334.8600232427316
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  9.48885D-01    |proj g|=  2.11514D-01

At iterate    5    f=  9.07891D-01    |proj g|=  1.20134D-02

At iterate   10    f=  9.06644D-01    |proj g|=  2.28308D-02

At iterate   15    f=  9.06352D-01    |proj g|=  5.57299D-07

           * * *
```

```
Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4     15     17      1     0     0   5.573D-07   9.064D-01
  F =  0.90635210512665154

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
312.5343073225549
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  1.06359D+00    |proj g|=  4.88304D-01
 This problem is unconstrained.
At iterate    5    f=  8.44257D-01    |proj g|=  3.85457D-02

At iterate   10    f=  8.42476D-01    |proj g|=  6.34295D-03

At iterate   15    f=  8.41092D-01    |proj g|=  1.47751D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     18     20      1     0     0   5.012D-06   8.411D-01
  F =  0.84109021131971651

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
292.60631100342476
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            3     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  9.13735D-01    |proj g|=  1.25224D-05

           * * *

Tit   = total number of iterations
```

```
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    3      1      9      1     0     0   1.561D-05   9.137D-01
  F =  0.91373525829533042

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
 This problem is unconstrained.
 This problem is unconstrained.
313.01504678723103
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  9.14152D-01    |proj g|=  6.29700D-02

At iterate    5    f=  9.12533D-01    |proj g|=  7.51846D-03

At iterate   10    f=  9.12091D-01    |proj g|=  9.28188D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4     10     13      1     0     0   9.282D-06   9.121D-01
  F =  0.91209094334288887

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
314.46255696321066
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  9.36211D-01    |proj g|=  2.03046D-01
 This problem is unconstrained.
At iterate    5    f=  9.07174D-01    |proj g|=  2.74877D-02

At iterate   10    f=  9.05712D-01    |proj g|=  4.59025D-03
```

```
           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     14     18      1     0     0   7.568D-06   9.057D-01
  F =  0.90565344930868952

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
314.2995589677197
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  1.17814D+00    |proj g|=  6.50785D-01

At iterate    5    f=  8.43670D-01    |proj g|=  5.28640D-02

At iterate   10    f=  8.37323D-01    |proj g|=  1.47477D-02

At iterate   15    f=  8.34759D-01    |proj g|=  5.22156D-02

At iterate   20    f=  8.27582D-01    |proj g|=  8.25568D-02

At iterate   25    f=  8.18597D-01    |proj g|=  5.72696D-03

At iterate   30    f=  8.18551D-01    |proj g|=  1.28837D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     31     42      1     0     0   4.882D-06   8.186D-01
  F =  0.81855149436487751

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
287.03330210659885
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
```

```
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.43483D-01    |proj g|=  1.18600D-05
 This problem is unconstrained.

 Warning:  more than 10 function and gradient
   evaluations in the last line search.  Termination
   may possibly be caused by a bad search direction.
 This problem is unconstrained.
           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4      1     18      1     0     0   1.196D-05   8.435D-01
  F =  0.84348280956592836

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
291.41022401415194
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.43616D-01    |proj g|=  1.52437D-02

At iterate    5    f=  8.43415D-01    |proj g|=  7.17248D-04

At iterate   10    f=  8.43413D-01    |proj g|=  1.92698D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     10     14      1     0     0   1.927D-06   8.434D-01
  F =  0.84341312369450860

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
293.3868095613549
RUNNING THE L-BFGS-B CODE

           * * *
```

```
Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.69154D-01    |proj g|=  1.47850D-01
 This problem is unconstrained.
At iterate    5    f=  8.44466D-01    |proj g|=  1.40390D-02

At iterate   10    f=  8.43581D-01    |proj g|=  7.74130D-03

At iterate   15    f=  8.43384D-01    |proj g|=  1.37885D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     17     20      1     0     0   3.633D-06   8.434D-01
  F =  0.84338413007631652

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
295.37706770564233
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  1.12996D+00    |proj g|=  5.88653D-01
 This problem is unconstrained.
At iterate    5    f=  8.37087D-01    |proj g|=  3.54428D-02

At iterate   10    f=  8.29013D-01    |proj g|=  2.29499D-02

At iterate   15    f=  8.28539D-01    |proj g|=  1.71291D-03

At iterate   20    f=  8.28516D-01    |proj g|=  3.34127D-03

At iterate   25    f=  8.28496D-01    |proj g|=  3.94142D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *
```

```
   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     26     30      1     0     0   1.152D-05   8.285D-01
  F =  0.82849592339092648

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
292.3746302593513
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            2     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.30441D-01    |proj g|=  1.23660D-01

At iterate    5    f=  8.28365D-01    |proj g|=  1.03234D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    2      6      8      1     0     0   2.528D-06   8.284D-01
  F =  0.82836455049018998

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
282.3304889647038
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            3     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.59501D-01    |proj g|=  1.31450D-01

At iterate    5    f=  7.49855D-01    |proj g|=  1.59208D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    3      7     10      1     0     0   2.326D-06   7.499D-01
  F =  0.74985373143543121
```

```
CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
257.95085376230486
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.59472D-01    |proj g|=  2.44473D-01
 This problem is unconstrained.
 This problem is unconstrained.
 This problem is unconstrained.
At iterate    5    f=  7.10406D-01    |proj g|=  4.36525D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4      8     10      1     0     0   6.555D-06   7.104D-01
  F =  0.71038670940110238

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
246.68993435877042
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.62157D-01    |proj g|=  2.83905D-01
 This problem is unconstrained.
At iterate    5    f=  6.62167D-01    |proj g|=  2.52605D-02

At iterate   10    f=  6.59498D-01    |proj g|=  4.23839D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     12     15      1     0     0   1.494D-06   6.595D-01
  F =  0.65949817977189351
```

```
CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
231.5913884033562
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            3     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.78040D-01    |proj g|=  1.15379D-01

At iterate    5    f=  7.70057D-01    |proj g|=  3.62184D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    3      7     11      1     0     0   2.899D-05   7.701D-01
  F =  0.77005685316675943

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
264.7391026640312
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.60520D-01    |proj g|=  1.32242D-01

At iterate    5    f=  7.52409D-01    |proj g|=  1.83545D-02
 This problem is unconstrained.
 This problem is unconstrained.
At iterate   10    f=  7.50046D-01    |proj g|=  1.05148D+00

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4     14     35      1     0     0   1.541D-02   7.499D-01
  F =  0.74985403097174963
```

```
CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
259.9509544065079
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.52526D-01    |proj g|=  2.39706D-01
 This problem is unconstrained.
At iterate    5    f=  7.09512D-01    |proj g|=  6.82959D-03

At iterate   10    f=  7.08959D-01    |proj g|=  7.49596D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     14     16      1     0     0   1.992D-06   7.089D-01
  F =  0.70890555827273394

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
248.1922675796386
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.26350D-01    |proj g|=  4.85374D-01

At iterate    5    f=  6.61421D-01    |proj g|=  1.82044D-02

At iterate   10    f=  6.59936D-01    |proj g|=  3.91792D-03

At iterate   15    f=  6.59121D-01    |proj g|=  1.75667D-02

At iterate   20    f=  6.58986D-01    |proj g|=  2.24467D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value
```

```
           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     21     26      1     0     0   1.150D-06   6.590D-01
  F =  0.65898620777718286

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
233.41936581313342
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.21917D-01    |proj g|=  8.34075D-02

At iterate    5    f=  7.13320D-01    |proj g|=  1.32730D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4      8     11      1     0     0   4.341D-06   7.133D-01
  F =  0.71331866957844359

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
247.67507297835704
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.20155D-01    |proj g|=  8.42298D-02
 This problem is unconstrained.
 This problem is unconstrained.
At iterate    5    f=  7.14744D-01    |proj g|=  1.02042D-02

At iterate   10    f=  7.12641D-01    |proj g|=  4.62759D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value
```

```
           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     13     16      1     0     0   4.118D-07   7.126D-01
  F =  0.71264085041173042

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
249.44732573834142
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.35494D-01    |proj g|=  1.94317D-01
 This problem is unconstrained.
At iterate    5    f=  7.04269D-01    |proj g|=  5.48314D-03

At iterate   10    f=  7.03720D-01    |proj g|=  2.84442D-03

At iterate   15    f=  7.03661D-01    |proj g|=  4.42061D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     17     22      1     0     0   5.554D-06   7.037D-01
  F =  0.70366117986316745

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
248.43015643402427
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  9.14556D-01    |proj g|=  6.54963D-01
 This problem is unconstrained.
At iterate    5    f=  6.61296D-01    |proj g|=  3.35109D-02

At iterate   10    f=  6.58660D-01    |proj g|=  1.50535D-02

At iterate   15    f=  6.58455D-01    |proj g|=  4.51362D-03

At iterate   20    f=  6.58163D-01    |proj g|=  2.30204D-03

At iterate   25    f=  6.58150D-01    |proj g|=  1.05825D-05
```

```
           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     26     29      1     0     0   4.716D-06   6.581D-01
  F =  0.65814980831947145

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
235.1383355953424
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.77095D-01    |proj g|=  8.24161D-02
 This problem is unconstrained.
At iterate    5    f=  6.66624D-01    |proj g|=  4.75941D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5      7     10      1     0     0   9.166D-06   6.666D-01
  F =  0.66662357012002871

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
233.98551956032966
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.76422D-01    |proj g|=  6.74855D-02
 This problem is unconstrained.
At iterate    5    f=  6.66981D-01    |proj g|=  6.18803D-03

At iterate   10    f=  6.66226D-01    |proj g|=  4.86312D-04

           * * *
```

```
Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     12     14      1     0     0   3.446D-06   6.662D-01
  F =  0.66622587475272099

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
235.85189391691426
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.99958D-01    |proj g|=  1.84397D-01

At iterate    5    f=  6.66805D-01    |proj g|=  6.81697D-03
 This problem is unconstrained.
At iterate   10    f=  6.66245D-01    |proj g|=  9.23269D-04

At iterate   15    f=  6.66224D-01    |proj g|=  1.17618D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     17     21      1     0     0   2.977D-06   6.662D-01
  F =  0.66622417115511756

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
237.8513215081195
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.76710D-01    |proj g|=  5.36461D-01
 This problem is unconstrained.
At iterate    5    f=  6.68835D-01    |proj g|=  1.72429D-02
```

```
At iterate   10    f=  6.61124D-01    |proj g|=  2.27772D-02

At iterate   15    f=  6.58234D-01    |proj g|=  1.75711D-03

At iterate   20    f=  6.58225D-01    |proj g|=  4.93626D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     22     27      1     0     0   6.957D-07   6.582D-01
  F =  0.65822531039357213

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
237.16370429224023
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            3     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.26088D-01    |proj g|=  7.63604D-02

At iterate    5    f=  8.23910D-01    |proj g|=  8.23384D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    3      7     10      1     0     0   5.131D-06   8.239D-01
  F =  0.82390935044678648

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
282.8335417501203
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.53088D-01    |proj g|=  9.56542D-02
```

```
At iterate    5    f=  7.43026D-01    |proj g|=  4.28046D-03

At iterate   10    f=  7.43008D-01    |proj g|=  1.29871D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4     10     13      1     0     0   1.299D-06   7.430D-01
  F =  0.74300815112566165

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
257.6507387782223
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.57573D-01    |proj g|=  2.51950D-01
 This problem is unconstrained.
 This problem is unconstrained.
 This problem is unconstrained.
At iterate    5    f=  7.05660D-01    |proj g|=  2.77819D-02

At iterate   10    f=  7.04119D-01    |proj g|=  2.54992D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     11     14      1     0     0   2.055D-05   7.041D-01
  F =  0.70411860716195240

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
246.583852006416
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds
```

```
At iterate    0    f=  7.50591D-01    |proj g|=  3.02853D-01
 This problem is unconstrained.
At iterate    5    f=  6.53814D-01    |proj g|=  2.40697D-02

At iterate   10    f=  6.50561D-01    |proj g|=  5.44421D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     13     16      1     0     0   8.539D-06   6.506D-01
  F =  0.65055981101080151

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
230.5880964996293
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.74519D-01    |proj g|=  8.68243D-02

At iterate    5    f=  7.64536D-01    |proj g|=  1.10228D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4      8     12      1     0     0   3.872D-06   7.645D-01
  F =  0.76453468565423288

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
264.88365437982225
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds
```

```
At iterate    0    f=  7.53307D-01    |proj g|=  9.73976D-02

At iterate    5    f=  7.44066D-01    |proj g|=  1.33054D-02

At iterate   10    f=  7.43687D-01    |proj g|=  4.28351D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     12     15      1     0     0   1.109D-06   7.437D-01
  F =  0.74368721058678644

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
 This problem is unconstrained.
 This problem is unconstrained.
259.8789027571603
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.49588D-01    |proj g|=  2.46761D-01

At iterate    5    f=  7.03745D-01    |proj g|=  5.29776D-03
 This problem is unconstrained.
At iterate   10    f=  7.02969D-01    |proj g|=  9.30817D-03

At iterate   15    f=  7.02896D-01    |proj g|=  1.19902D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     16     20      1     0     0   8.317D-06   7.029D-01
  F =  0.70289592245529808

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
248.17302994498016
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *
```

```
Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.06662D-01    |proj g|=  4.80949D-01

At iterate    5    f=  6.52709D-01    |proj g|=  2.53028D-02

At iterate   10    f=  6.50904D-01    |proj g|=  2.78783D-03

At iterate   15    f=  6.50277D-01    |proj g|=  2.12592D-02

At iterate   20    f=  6.50110D-01    |proj g|=  9.82160D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     21     25      1     0     0   1.236D-04   6.501D-01
  F =  0.65011048943738603

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
232.4371244509617
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.18787D-01    |proj g|=  9.59026D-02

At iterate    5    f=  7.08106D-01    |proj g|=  2.06172D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5      8     10      1     0     0   2.490D-05   7.081D-01
  F =  0.70810558300131410

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
247.92347588844154
RUNNING THE L-BFGS-B CODE
```

```
           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.17275D-01    |proj g|=  6.92563D-02
 This problem is unconstrained.
 This problem is unconstrained.
At iterate    5    f=  7.09627D-01    |proj g|=  1.51339D-02

At iterate   10    f=  7.05947D-01    |proj g|=  6.81795D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     14     17      1     0     0   1.443D-05   7.059D-01
  F =  0.70594578908045114

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
249.19778513103157
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.30144D-01    |proj g|=  2.09902D-01
 This problem is unconstrained.
At iterate    5    f=  6.95237D-01    |proj g|=  9.62762D-03

At iterate   10    f=  6.93459D-01    |proj g|=  1.15392D-02

At iterate   15    f=  6.93333D-01    |proj g|=  1.63103D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     17     21      1     0     0   3.401D-06   6.933D-01
  F =  0.69333279497058697
```

```
CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
246.95981911011722
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.78307D-01    |proj g|=  5.99739D-01
 This problem is unconstrained.
At iterate    5    f=  6.54357D-01    |proj g|=  3.53427D-02

At iterate   10    f=  6.50627D-01    |proj g|=  8.18044D-03

At iterate   15    f=  6.50192D-01    |proj g|=  2.68887D-03

At iterate   20    f=  6.49577D-01    |proj g|=  7.49018D-03

At iterate   25    f=  6.49169D-01    |proj g|=  2.04284D-03

At iterate   30    f=  6.49165D-01    |proj g|=  2.64487D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     31     36      1     0     0   7.220D-06   6.492D-01
  F =  0.64916452272641945

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
234.11927963607693
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.77720D-01    |proj g|=  9.54652D-02
 This problem is unconstrained.
At iterate    5    f=  6.59496D-01    |proj g|=  4.15299D-02

At iterate   10    f=  6.58518D-01    |proj g|=  1.97529D-03

At iterate   15    f=  6.58516D-01    |proj g|=  2.05153D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
```

```
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     15     31      1     0     0   2.052D-03   6.585D-01
  F =  0.65851584470945967

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
233.26132382237844
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.77125D-01    |proj g|=  8.00668D-02
 This problem is unconstrained.
At iterate    5    f=  6.61527D-01    |proj g|=  1.63720D-02

At iterate   10    f=  6.58561D-01    |proj g|=  6.44611D-03

At iterate   15    f=  6.58515D-01    |proj g|=  1.76476D-03

At iterate   20    f=  6.58513D-01    |proj g|=  3.78371D-03

At iterate   25    f=  6.58430D-01    |proj g|=  8.05060D-02

At iterate   30    f=  6.58270D-01    |proj g|=  5.15799D-01

At iterate   35    f=  6.58133D-01    |proj g|=  1.67841D-02

At iterate   40    f=  6.58129D-01    |proj g|=  1.18111D-02

At iterate   45    f=  6.58127D-01    |proj g|=  9.97962D-04

At iterate   50    f=  6.58127D-01    |proj g|=  8.65448D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     50     70      1     0     0   8.654D-04   6.581D-01
  F =  0.65812728484547200

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
235.1307677080786
RUNNING THE L-BFGS-B CODE
```

```
           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.00515D-01    |proj g|=  2.00286D-01
 This problem is unconstrained.
At iterate    5    f=  6.60804D-01    |proj g|=  9.85993D-03

At iterate   10    f=  6.58362D-01    |proj g|=  7.35791D-03

At iterate   15    f=  6.58014D-01    |proj g|=  4.11838D-03

At iterate   20    f=  6.57980D-01    |proj g|=  2.12878D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     20     32      1     0     0   2.129D-03   6.580D-01
  F =  0.65797968137250673

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
237.08117294116227
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.51337D-01    |proj g|=  5.15679D-01
 This problem is unconstrained.
At iterate    5    f=  6.62396D-01    |proj g|=  2.53038D-02

At iterate   10    f=  6.52653D-01    |proj g|=  3.49641D-02

At iterate   15    f=  6.48882D-01    |proj g|=  1.06971D-02

At iterate   20    f=  6.48531D-01    |proj g|=  2.83413D-02

At iterate   25    f=  6.48520D-01    |proj g|=  1.19757D-03

At iterate   30    f=  6.48519D-01    |proj g|=  1.14967D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
```

```
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     30     40      1     0     0   1.150D-04   6.485D-01
  F =  0.64851908959036009

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
235.90241410236098
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.21138D-01    |proj g|=  1.20245D-01

At iterate    5    f=  8.14617D-01    |proj g|=  1.40544D-02

At iterate   10    f=  8.14406D-01    |proj g|=  4.39436D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4     10     13      1     0     0   4.394D-06   8.144D-01
  F =  0.81440587199108583

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
281.64037298900485
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.50224D-01    |proj g|=  1.28938D-01
 This problem is unconstrained.
 This problem is unconstrained.
At iterate    5    f=  7.37212D-01    |proj g|=  2.18112D-02

At iterate   10    f=  7.36504D-01    |proj g|=  6.08097D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
```

```
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     12     15      1     0     0   8.463D-06   7.365D-01
  F =  0.73650443302061552

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
257.4654894949268
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.51036D-01    |proj g|=  2.39941D-01
 This problem is unconstrained.
At iterate    5    f=  6.97433D-01    |proj g|=  1.84132D-02

At iterate   10    f=  6.96886D-01    |proj g|=  1.17435D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     13     15      1     0     0   6.971D-06   6.969D-01
  F =  0.69688601069630796

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
246.15369959395946
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.43776D-01    |proj g|=  2.68832D-01
 This problem is unconstrained.
At iterate    5    f=  6.48075D-01    |proj g|=  3.58243D-02

At iterate   10    f=  6.43273D-01    |proj g|=  1.77765D-03

At iterate   15    f=  6.43259D-01    |proj g|=  6.29579D-06

           * * *
```

```
Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     15     18      1     0     0   6.296D-06   6.433D-01
  F =  0.64325910432443434

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
230.13505905300994
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.74291D-01    |proj g|=  1.30932D-01

At iterate    5    f=  7.62174D-01    |proj g|=  2.00068D-02

At iterate   10    f=  7.61714D-01    |proj g|=  4.08662D-04
 This problem is unconstrained.
 This problem is unconstrained.
           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     12     15      1     0     0   5.695D-06   7.617D-01
  F =  0.76171358963564784

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
265.93576611757766
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.50363D-01    |proj g|=  1.30542D-01

At iterate    5    f=  7.38232D-01    |proj g|=  2.31131D-02

At iterate   10    f=  7.36664D-01    |proj g|=  1.58959D-03
```

```
At iterate   15    f=  7.36507D-01    |proj g|=  5.42583D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     17     27      1     0     0   6.629D-05   7.365D-01
  F =  0.73650724348068641

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
259.46643380951065
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.43094D-01    |proj g|=  2.32287D-01
 This problem is unconstrained.
At iterate    5    f=  6.96697D-01    |proj g|=  1.43016D-02

At iterate   10    f=  6.95850D-01    |proj g|=  4.68647D-03

At iterate   15    f=  6.95462D-01    |proj g|=  1.83859D-03

At iterate   20    f=  6.95459D-01    |proj g|=  4.72526D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     20     25      1     0     0   4.725D-06   6.955D-01
  F =  0.69545876006092111

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
247.6741433804695
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10
```

```
At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.99865D-01    |proj g|=  4.33212D-01

At iterate    5    f=  6.47713D-01    |proj g|=  3.79531D-02

At iterate   10    f=  6.43534D-01    |proj g|=  2.32821D-03

At iterate   15    f=  6.43095D-01    |proj g|=  6.44156D-03

At iterate   20    f=  6.42911D-01    |proj g|=  2.31805D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     23     27      1     0     0   1.906D-05   6.429D-01
  F =  0.64291139111638829

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
232.01822741510645
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.17402D-01    |proj g|=  9.48132D-02
 This problem is unconstrained.
At iterate    5    f=  7.02377D-01    |proj g|=  1.48245D-02

At iterate   10    f=  7.02064D-01    |proj g|=  5.17010D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     12     16      1     0     0   2.014D-05   7.021D-01
  F =  0.70206413399167156

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
247.89354902120164
RUNNING THE L-BFGS-B CODE
```

```
           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.16002D-01    |proj g|=  1.00704D-01
 This problem is unconstrained.
At iterate    5    f=  7.04714D-01    |proj g|=  3.04403D-02

At iterate   10    f=  7.01659D-01    |proj g|=  1.49126D-02

At iterate   15    f=  7.00299D-01    |proj g|=  1.75608D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     17     21      1     0     0   3.577D-05   7.003D-01
  F =  0.70029882410877642

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
249.30040490054887
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.24489D-01    |proj g|=  1.98986D-01

At iterate    5    f=  6.87817D-01    |proj g|=  2.32163D-02
 This problem is unconstrained.
At iterate   10    f=  6.85942D-01    |proj g|=  5.14514D-03

At iterate   15    f=  6.85128D-01    |proj g|=  3.66570D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     19     23      1     0     0   6.915D-06   6.851D-01
  F =  0.68512825765437990
```

```
CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
246.20309457187165
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.69957D-01    |proj g|=  5.45411D-01
 This problem is unconstrained.
At iterate    5    f=  6.46605D-01    |proj g|=  2.92369D-02

At iterate   10    f=  6.43571D-01    |proj g|=  8.03727D-03

At iterate   15    f=  6.43094D-01    |proj g|=  1.76120D-03

At iterate   20    f=  6.42773D-01    |proj g|=  7.45039D-03

At iterate   25    f=  6.41864D-01    |proj g|=  4.12166D-03

At iterate   30    f=  6.41829D-01    |proj g|=  5.70427D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     34     40      1     0     0   4.696D-06   6.418D-01
  F =  0.64182878746527827

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
233.6544725883335
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.75215D-01    |proj g|=  1.00220D-01
 This problem is unconstrained.
At iterate    5    f=  6.57304D-01    |proj g|=  9.48894D-02

At iterate   10    f=  6.53962D-01    |proj g|=  1.48519D-02
 Warning:  more than 10 function and gradient
   evaluations in the last line search.  Termination
   may possibly be caused by a bad search direction.
 This problem is unconstrained.
           * * *

Tit   = total number of iterations
```

```
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     11     34      1     0     0   1.485D-02   6.540D-01
  F =  0.65396239615634910

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
233.7313651085333
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.74648D-01    |proj g|=  1.01022D-01

At iterate    5    f=  6.57325D-01    |proj g|=  4.47852D-02

At iterate   10    f=  6.54185D-01    |proj g|=  4.21309D-02

At iterate   15    f=  6.54010D-01    |proj g|=  8.59748D-03

At iterate   20    f=  6.53947D-01    |proj g|=  2.00456D-02

At iterate   25    f=  6.53946D-01    |proj g|=  4.38169D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     29     53      1     0     0   1.649D-03   6.539D-01
  F =  0.65394586389942277

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
235.72581027020604
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.97305D-01    |proj g|=  1.90426D-01
 This problem is unconstrained.
```

```
At iterate    5    f=  6.57007D-01    |proj g|=  1.73955D-02

At iterate   10    f=  6.53847D-01    |proj g|=  1.06436D-02

At iterate   15    f=  6.53494D-01    |proj g|=  1.65000D-02

At iterate   20    f=  6.53402D-01    |proj g|=  5.00472D-03

At iterate   25    f=  6.53385D-01    |proj g|=  4.46784D-04

At iterate   30    f=  6.53385D-01    |proj g|=  4.94503D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     31     43      1     0     0   2.739D-03   6.534D-01
  F =  0.65338467475113848

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
237.53725071638252
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.44310D-01    |proj g|=  5.04630D-01

At iterate    5    f=  6.55864D-01    |proj g|=  4.33466D-02

At iterate   10    f=  6.48780D-01    |proj g|=  3.38697D-02

At iterate   15    f=  6.42363D-01    |proj g|=  1.68626D-02

At iterate   20    f=  6.41353D-01    |proj g|=  5.22322D-03

At iterate   25    f=  6.41206D-01    |proj g|=  9.18739D-04

At iterate   30    f=  6.41204D-01    |proj g|=  4.14275D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *
```

```
   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     31     39      1     0     0   1.952D-05   6.412D-01
  F =  0.64120363681203629

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
235.4444219688442
RUNNING THE L-BFGS-B CODE

           * * *
 This problem is unconstrained.
 This problem is unconstrained.
 This problem is unconstrained.
Machine precision = 2.220D-16
 N =            2     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.95902D-01    |proj g|=  1.80231D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    2      1      5      1     0     0   1.049D-05   8.959D-01
  F =  0.89590210367205392

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
305.0231068338101
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            3     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.26672D-01    |proj g|=  5.22545D-02

At iterate    5    f=  8.23396D-01    |proj g|=  6.63371D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    3      8     12      1     0     0   1.093D-05   8.234D-01
```

```
  F =  0.82339620999231489

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
282.6611265574178
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.05545D-01    |proj g|=  2.22568D-01

At iterate    5    f=  7.69155D-01    |proj g|=  1.63081D-02

At iterate   10    f=  7.68881D-01    |proj g|=  1.51863D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4     11     13      1     0     0   4.311D-07   7.689D-01
  F =  0.76888147282791885

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
266.3441748701807
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.52855D-01    |proj g|=  4.91827D-01
 This problem is unconstrained.
At iterate    5    f=  7.17006D-01    |proj g|=  5.92354D-02

At iterate   10    f=  7.09863D-01    |proj g|=  5.03701D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
```

```
    5     12     14      1     0     0   3.864D-06   7.099D-01
  F =  0.70986330458190028

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
248.5140703395185
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            3     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.36436D-01    |proj g|=  3.48415D-02

At iterate    5    f=  8.35310D-01    |proj g|=  1.63260D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    3      7      9      1     0     0   4.283D-06   8.353D-01
  F =  0.83530920465063574

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
286.6638927626136
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.27300D-01    |proj g|=  4.50971D-02

At iterate    5    f=  8.21418D-01    |proj g|=  9.59003D-03

At iterate   10    f=  8.21268D-01    |proj g|=  5.93968D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4     10     13      1     0     0   5.940D-06   8.213D-01
  F =  0.82126767041329951
```

```
CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
283.94593725886864
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.99207D-01    |proj g|=  2.03616D-01
 This problem is unconstrained.
 This problem is unconstrained.
 This problem is unconstrained.
At iterate    5    f=  7.67081D-01    |proj g|=  3.42964D-03

At iterate   10    f=  7.66871D-01    |proj g|=  7.72442D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     13     16      1     0     0   8.213D-06   7.669D-01
  F =  0.76685171436551391

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
267.6621760268127
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  9.46112D-01    |proj g|=  7.78727D-01
 This problem is unconstrained.
At iterate    5    f=  7.15045D-01    |proj g|=  5.92912D-02

At iterate   10    f=  7.10555D-01    |proj g|=  3.54398D-03

At iterate   15    f=  7.09521D-01    |proj g|=  6.03635D-03

At iterate   20    f=  7.09451D-01    |proj g|=  3.07046D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
```

```
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     21     25      1     0     0   1.371D-05   7.095D-01
  F =  0.70945083639773288

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
250.37548102963825
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.63355D-01    |proj g|=  4.93754D-02

At iterate    5    f=  7.61132D-01    |proj g|=  1.26502D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4      6      8      1     0     0   5.554D-06   7.611D-01
  F =  0.76113207546693951

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
263.74037735689166
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.63346D-01    |proj g|=  2.48933D-02

At iterate    5    f=  7.62080D-01    |proj g|=  2.95649D-02
 This problem is unconstrained.
 This problem is unconstrained.
At iterate   10    f=  7.60319D-01    |proj g|=  1.58316D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
```

```
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     14     23      1     0     0   1.552D-05   7.603D-01
  F =  0.76031819362822073

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
265.4669130590822
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.81480D-01    |proj g|=  1.64977D-01
 This problem is unconstrained.
At iterate    5    f=  7.60282D-01    |proj g|=  8.60639D-03

At iterate   10    f=  7.59834D-01    |proj g|=  7.77013D-04

At iterate   15    f=  7.59824D-01    |proj g|=  4.62555D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     16     20      1     0     0   1.101D-05   7.598D-01
  F =  0.75982414957925215

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
267.3009142586287
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  1.04738D+00    |proj g|=  9.81664D-01
 This problem is unconstrained.
At iterate    5    f=  7.12915D-01    |proj g|=  2.73809D-02

At iterate   10    f=  7.09495D-01    |proj g|=  1.83814D-03

At iterate   15    f=  7.09466D-01    |proj g|=  3.05339D-03

At iterate   20    f=  7.09081D-01    |proj g|=  4.92997D-03

At iterate   25    f=  7.09038D-01    |proj g|=  7.71599D-05
```

```
           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     26     34      1     0     0   6.290D-06   7.090D-01
  F =  0.70903769762797708

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
252.2366664030003
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.15533D-01    |proj g|=  9.03745D-02
 This problem is unconstrained.
At iterate    5    f=  7.09620D-01    |proj g|=  2.45064D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5      9     12      1     0     0   1.314D-05   7.096D-01
  F =  0.70960396290125127

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
248.42693153482043
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.15547D-01    |proj g|=  9.01102D-02
 This problem is unconstrained.
At iterate    5    f=  7.09755D-01    |proj g|=  1.25701D-02

At iterate   10    f=  7.08709D-01    |proj g|=  2.95629D-03
```

```
           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     13     16      1     0     0   4.429D-06   7.087D-01
  F =  0.70870262775345849

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
250.12408292516204
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.35580D-01    |proj g|=  1.60111D-01

At iterate    5    f=  7.09091D-01    |proj g|=  7.79543D-03
 This problem is unconstrained.
At iterate   10    f=  7.08530D-01    |proj g|=  9.52942D-04

At iterate   15    f=  7.08518D-01    |proj g|=  9.43567D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     18     20      1     0     0   6.426D-06   7.085D-01
  F =  0.70851749985015300

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
252.0618799496514
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  1.00784D+00    |proj g|=  8.21438D-01
 This problem is unconstrained.
At iterate    5    f=  7.18831D-01    |proj g|=  1.82600D-02
```

```
At iterate   10    f=  7.13115D-01    |proj g|=  2.26027D-02

At iterate   15    f=  7.08291D-01    |proj g|=  5.94671D-03

At iterate   20    f=  7.08267D-01    |proj g|=  9.89193D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     22     28      1     0     0   2.420D-05   7.083D-01
  F =  0.70826691161430932

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
253.97768230240794
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            3     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.33556D-01    |proj g|=  8.21707D-02

At iterate    5    f=  8.26302D-01    |proj g|=  2.14264D-02

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    3      9     17      1     0     0   1.245D-05   8.261D-01
  F =  0.82613784764737463

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
283.58231680951786
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.61693D-01    |proj g|=  1.09417D-01
```

```
 This problem is unconstrained.
 This problem is unconstrained.
 This problem is unconstrained.
At iterate    5    f=  7.44618D-01    |proj g|=  7.67522D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4      9     12      1     0     0   5.615D-06   7.445D-01
  F =  0.74453494734673664

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
258.1637423085035
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.61076D-01    |proj g|=  2.42857D-01

At iterate    5    f=  7.07892D-01    |proj g|=  3.36001D-02

At iterate   10    f=  7.06092D-01    |proj g|=  5.55644D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     13     16      1     0     0   3.137D-06   7.061D-01
  F =  0.70609215005642767

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
247.2469624189597
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds
```

```
At iterate    0    f=  7.64468D-01    |proj g|=  3.27068D-01
 This problem is unconstrained.
At iterate    5    f=  6.56580D-01    |proj g|=  3.94807D-02

At iterate   10    f=  6.52590D-01    |proj g|=  9.68651D-04

At iterate   15    f=  6.52586D-01    |proj g|=  3.39349D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     15     18      1     0     0   3.393D-06   6.526D-01
  F =  0.65258646980499468

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
231.26905385447822
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.75085D-01    |proj g|=  1.03619D-01

At iterate    5    f=  7.58853D-01    |proj g|=  6.45651D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4      9     12      1     0     0   7.541D-06   7.588D-01
  F =  0.75879733492855062

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
262.955904535993
RUNNING THE L-BFGS-B CODE

           * * *

 This problem is unconstrained.
 This problem is unconstrained.
Machine precision = 2.220D-16
```

```
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.62049D-01    |proj g|=  1.10516D-01

At iterate    5    f=  7.45912D-01    |proj g|=  1.75484D-02

At iterate   10    f=  7.45718D-01    |proj g|=  4.41902D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     13     16      1     0     0   8.005D-08   7.457D-01
  F =  0.74571731684611797

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
260.56101846029566
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.53376D-01    |proj g|=  2.35042D-01
 This problem is unconstrained.
At iterate    5    f=  7.06126D-01    |proj g|=  2.38635D-02

At iterate   10    f=  7.04800D-01    |proj g|=  9.13601D-03

At iterate   15    f=  7.04608D-01    |proj g|=  1.11060D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     16     19      1     0     0   7.314D-06   7.046D-01
  F =  0.70460773349200356

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
248.7481984533132
RUNNING THE L-BFGS-B CODE
```

```
           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.26418D-01    |proj g|=  5.23820D-01
 This problem is unconstrained.
At iterate    5    f=  6.54685D-01    |proj g|=  2.92359D-02

At iterate   10    f=  6.52887D-01    |proj g|=  2.74564D-03

At iterate   15    f=  6.52653D-01    |proj g|=  5.58338D-03

At iterate   20    f=  6.52375D-01    |proj g|=  3.83815D-04

At iterate   25    f=  6.52375D-01    |proj g|=  2.42551D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     25     29      1     0     0   2.426D-05   6.524D-01
  F =  0.65237477934055121

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
233.1979258584252
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.15919D-01    |proj g|=  8.89871D-02

At iterate    5    f=  7.01866D-01    |proj g|=  1.20260D-02
 This problem is unconstrained.
 This problem is unconstrained.
At iterate   10    f=  7.01475D-01    |proj g|=  2.50822D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *
```

```
   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     11     14      1     0     0   8.801D-06   7.015D-01
  F =  0.70147465413226739

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
245.69548378844183
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.14993D-01    |proj g|=  7.25010D-02

At iterate    5    f=  7.04098D-01    |proj g|=  1.45295D-02

At iterate   10    f=  6.99008D-01    |proj g|=  1.01771D-02

At iterate   15    f=  6.98593D-01    |proj g|=  2.98544D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     16     20      1     0     0   2.601D-06   6.986D-01
  F =  0.69859308938815323

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
246.72727803441947
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.34233D-01    |proj g|=  2.00912D-01
 This problem is unconstrained.
At iterate    5    f=  6.97022D-01    |proj g|=  1.52423D-02

At iterate   10    f=  6.95423D-01    |proj g|=  7.32450D-03

At iterate   15    f=  6.95151D-01    |proj g|=  6.60199D-04

At iterate   20    f=  6.95150D-01    |proj g|=  6.21087D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
```

```
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     20     22      1     0     0   6.211D-06   6.951D-01
  F =  0.69514978054584631

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
247.57032626340435
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  9.08263D-01    |proj g|=  6.75007D-01
 This problem is unconstrained.
At iterate    5    f=  6.56798D-01    |proj g|=  3.13552D-02

At iterate   10    f=  6.53026D-01    |proj g|=  7.23304D-03

At iterate   15    f=  6.52364D-01    |proj g|=  1.92192D-03

At iterate   20    f=  6.51981D-01    |proj g|=  9.43548D-03

At iterate   25    f=  6.51697D-01    |proj g|=  8.99864D-04

At iterate   30    f=  6.51695D-01    |proj g|=  2.57783D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     31     36      1     0     0   1.574D-05   6.517D-01
  F =  0.65169543995414492

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
234.9696678245927
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.75625D-01    |proj g|=  8.84375D-02
 This problem is unconstrained.
```

```
At iterate    5    f=  6.55403D-01    |proj g|=  3.75413D-02

At iterate   10    f=  6.54880D-01    |proj g|=  2.56283D-02

At iterate   15    f=  6.54832D-01    |proj g|=  1.49731D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     17     41      1     0     0   4.170D-04   6.548D-01
  F =  0.65483179865135865

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
232.0234843468565
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.75223D-01    |proj g|=  8.20770D-02
 Warning:  more than 10 function and gradient
   evaluations in the last line search.  Termination
   may possibly be caused by a bad search direction.
 This problem is unconstrained.
At iterate    5    f=  6.55017D-01    |proj g|=  1.50619D-02

At iterate   10    f=  6.54871D-01    |proj g|=  7.22712D-03

At iterate   15    f=  6.54840D-01    |proj g|=  2.12409D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     17     36      1     0     0   2.552D-04   6.548D-01
  F =  0.65483960492935955

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
234.0261072562648
RUNNING THE L-BFGS-B CODE

           * * *
```

```
Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.97181D-01    |proj g|=  1.92875D-01
 This problem is unconstrained.
At iterate    5    f=  6.55169D-01    |proj g|=  1.21256D-02

At iterate   10    f=  6.54665D-01    |proj g|=  1.29075D-03
  ys=-2.105E-04  -gs= 4.733E-05 BFGS update SKIPPED

At iterate   15    f=  6.54122D-01    |proj g|=  1.48932D-03

At iterate   20    f=  6.54120D-01    |proj g|=  1.72979D-03

At iterate   25    f=  6.54117D-01    |proj g|=  2.67144D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     25     38      1     1     0   2.671D-04   6.541D-01
  F =  0.65411739064914509

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
235.78344325811275
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.73555D-01    |proj g|=  5.47507D-01
 This problem is unconstrained.
At iterate    5    f=  6.65869D-01    |proj g|=  2.64466D-02

At iterate   10    f=  6.54584D-01    |proj g|=  2.92708D-02

At iterate   15    f=  6.51636D-01    |proj g|=  6.99098D-03

At iterate   20    f=  6.51218D-01    |proj g|=  1.06305D-03

At iterate   25    f=  6.51210D-01    |proj g|=  8.34611D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
```

```
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     25     29      1     0     0   8.346D-06   6.512D-01
  F =  0.65121048486497723

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
236.80672291463236
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.25638D-01    |proj g|=  4.42460D-02

At iterate    5    f=  8.24086D-01    |proj g|=  1.24405D-02

At iterate   10    f=  8.23281D-01    |proj g|=  3.74921D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4     13     16      1     0     0   6.062D-06   8.233D-01
  F =  0.82326992037347269

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
284.61869324548684
 This problem is unconstrained.
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.53120D-01    |proj g|=  7.42466D-02

At iterate    5    f=  7.43995D-01    |proj g|=  7.92191D-03

At iterate   10    f=  7.42165D-01    |proj g|=  4.71674D-03

At iterate   15    f=  7.42154D-01    |proj g|=  9.91780D-06

           * * *
```

```
Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     15     19      1     0     0   9.918D-06   7.422D-01
  F =  0.74215384844692656

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
259.36369307816733
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.57556D-01    |proj g|=  2.56532D-01
 This problem is unconstrained.
At iterate    5    f=  7.06233D-01    |proj g|=  3.44966D-02

At iterate   10    f=  7.04647D-01    |proj g|=  1.99385D-02

At iterate   15    f=  7.03319D-01    |proj g|=  4.38723D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     18     20      1     0     0   4.877D-06   7.033D-01
  F =  0.70331595350715359

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
248.3141603784036
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.54990D-01    |proj g|=  3.47445D-01
 This problem is unconstrained.
At iterate    5    f=  6.54252D-01    |proj g|=  3.83409D-02

At iterate   10    f=  6.50705D-01    |proj g|=  7.51279D-03
```

```
At iterate   15    f=  6.49488D-01    |proj g|=  4.85340D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     19     23      1     0     0   2.276D-05   6.495D-01
  F =  0.64946776394862826

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
232.2211686867391
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.69717D-01    |proj g|=  7.91779D-02

At iterate    5    f=  7.61247D-01    |proj g|=  8.58270D-03

At iterate   10    f=  7.58812D-01    |proj g|=  4.51726D-03

At iterate   15    f=  7.58797D-01    |proj g|=  7.61546D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     15     18      1     0     0   7.615D-06   7.588D-01
  F =  0.75879716831911370

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
264.9558485552222
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.53464D-01    |proj g|=  6.90645D-02
```

```
At iterate    5    f=  7.45210D-01    |proj g|=  2.54624D-02
 This problem is unconstrained.
 This problem is unconstrained.
At iterate   10    f=  7.43235D-01    |proj g|=  2.05847D-02

At iterate   15    f=  7.42837D-01    |proj g|=  4.85807D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     18     23      1     0     0   3.853D-06   7.428D-01
  F =  0.74283689098510497

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
261.59319537099526
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.49751D-01    |proj g|=  2.50725D-01
 This problem is unconstrained.
At iterate    5    f=  7.04208D-01    |proj g|=  8.95698D-03

At iterate   10    f=  7.02275D-01    |proj g|=  1.22198D-02

At iterate   15    f=  7.02010D-01    |proj g|=  4.67186D-04

At iterate   20    f=  7.02003D-01    |proj g|=  2.72302D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     22     27      1     0     0   3.637D-06   7.020D-01
  F =  0.70200287532816308

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
249.87296611026278
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE
```

```
           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.16402D-01    |proj g|=  5.45084D-01

At iterate    5    f=  6.53417D-01    |proj g|=  2.17724D-02

At iterate   10    f=  6.51268D-01    |proj g|=  7.57050D-03

At iterate   15    f=  6.49421D-01    |proj g|=  9.66003D-03

At iterate   20    f=  6.49309D-01    |proj g|=  6.34530D-03

At iterate   25    f=  6.49132D-01    |proj g|=  4.29694D-03

At iterate   30    f=  6.49128D-01    |proj g|=  5.55785D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     34     39      1     0     0   3.427D-05   6.491D-01
  F =  0.64912808516182186

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
234.10703661437213
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.13212D-01    |proj g|=  9.58051D-02
 This problem is unconstrained.
At iterate    5    f=  7.03462D-01    |proj g|=  1.05917D-02

At iterate   10    f=  7.01458D-01    |proj g|=  9.35678D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value
```

```
           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     13     17      1     0     0   7.263D-06   7.015D-01
  F =  0.70145614948136747

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
247.68926622573946
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.11667D-01    |proj g|=  6.88739D-02
 This problem is unconstrained.
At iterate    5    f=  7.05915D-01    |proj g|=  2.16045D-02

At iterate   10    f=  6.99390D-01    |proj g|=  1.21170D-02

At iterate   15    f=  6.98586D-01    |proj g|=  4.88878D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     19     23      1     0     0   2.881D-06   6.986D-01
  F =  0.69856798788516150

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
248.71884392941425
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.30310D-01    |proj g|=  2.10093D-01

 This problem is unconstrained.
At iterate    5    f=  6.96598D-01    |proj g|=  8.47574D-03

At iterate   10    f=  6.92621D-01    |proj g|=  1.21858D-02

At iterate   15    f=  6.92183D-01    |proj g|=  2.36039D-04

At iterate   20    f=  6.92183D-01    |proj g|=  3.64190D-05

           * * *
```

```
Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     21     24      1     0     0   7.375D-06   6.922D-01
  F =  0.69218328899415105

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
248.57358510203474
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.94229D-01    |proj g|=  6.85459D-01
 This problem is unconstrained.
At iterate    5    f=  6.54099D-01    |proj g|=  3.00307D-02

At iterate   10    f=  6.50176D-01    |proj g|=  9.50072D-03

At iterate   15    f=  6.49478D-01    |proj g|=  3.57097D-03

At iterate   20    f=  6.48826D-01    |proj g|=  2.04205D-03

At iterate   25    f=  6.48607D-01    |proj g|=  7.63244D-03

At iterate   30    f=  6.48213D-01    |proj g|=  3.14660D-03

At iterate   35    f=  6.48203D-01    |proj g|=  2.83185D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     39     45      1     0     0   3.597D-06   6.482D-01
  F =  0.64820257589095165

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
235.79606549935974
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10
```

```
At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.72154D-01    |proj g|=  9.46899D-02
 This problem is unconstrained.
At iterate    5    f=  6.58243D-01    |proj g|=  8.37350D-03

At iterate   10    f=  6.55782D-01    |proj g|=  3.08309D-02

At iterate   15    f=  6.54837D-01    |proj g|=  7.26547D-02

At iterate   20    f=  6.54824D-01    |proj g|=  1.85150D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     24     34      1     0     0   2.671D-06   6.548D-01
  F =  0.65482357138658309

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
234.02071998589193
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.71513D-01    |proj g|=  7.89745D-02

At iterate    5    f=  6.58518D-01    |proj g|=  9.27068D-03
 This problem is unconstrained.
At iterate   10    f=  6.55371D-01    |proj g|=  2.05756D-02

At iterate   15    f=  6.54217D-01    |proj g|=  3.91408D-02

At iterate   20    f=  6.54095D-01    |proj g|=  3.02485D-03

At iterate   25    f=  6.54080D-01    |proj g|=  7.48825D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
```

```
    8     27     63      1     0     0   2.179D-04   6.541D-01
  F =  0.65407981404455440

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
235.7708175189703
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.95265D-01    |proj g|=  2.01665D-01
 Warning:  more than 10 function and gradient
   evaluations in the last line search.  Termination
   may possibly be caused by a bad search direction.
 This problem is unconstrained.
At iterate    5    f=  6.57776D-01    |proj g|=  7.43623D-03

At iterate   10    f=  6.55467D-01    |proj g|=  1.87462D-02
  ys=-5.963E-04  -gs= 2.300E-04 BFGS update SKIPPED

At iterate   15    f=  6.54235D-01    |proj g|=  2.07145D-02

At iterate   20    f=  6.54162D-01    |proj g|=  7.59959D-03

At iterate   25    f=  6.54106D-01    |proj g|=  8.19217D-03

At iterate   30    f=  6.54065D-01    |proj g|=  3.84370D-03

At iterate   35    f=  6.54057D-01    |proj g|=  5.20266D-04

At iterate   40    f=  6.54056D-01    |proj g|=  5.24425D-04
 Bad direction in the line search;
   refresh the lbfgs memory and restart the iteration.

 Warning:  more than 10 function and gradient
   evaluations in the last line search.  Termination
   may possibly be caused by a bad search direction.
 This problem is unconstrained.
           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     41     88      2     1     0   5.244D-04   6.541D-01
  F =  0.65405626842087816

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
237.76290618941505
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
```

```
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.65976D-01    |proj g|=  5.61359D-01

At iterate    5    f=  6.61771D-01    |proj g|=  1.60679D-02

At iterate   10    f=  6.53270D-01    |proj g|=  1.57522D-02

At iterate   15    f=  6.47824D-01    |proj g|=  6.58472D-03

At iterate   20    f=  6.47540D-01    |proj g|=  7.20954D-03

At iterate   25    f=  6.47510D-01    |proj g|=  9.23983D-04

At iterate   30    f=  6.47509D-01    |proj g|=  7.12384D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     32     39      1     0     0   7.454D-06   6.475D-01
  F =  0.64750904022324152

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
237.56303751500914
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.23060D-01    |proj g|=  6.80524D-02

At iterate    5    f=  8.18939D-01    |proj g|=  2.31602D-03

At iterate   10    f=  8.18470D-01    |proj g|=  9.22994D-03

At iterate   15    f=  8.18435D-01    |proj g|=  1.16863D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
```

```
    5     16     31      1     0     0   1.109D-05   8.184D-01
  F =  0.81843507975067253

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
284.99418679622596
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.51681D-01    |proj g|=  7.86058D-02
 This problem is unconstrained.

 Warning:  more than 10 function and gradient
   evaluations in the last line search.  Termination
   may possibly be caused by a bad search direction.
 This problem is unconstrained.
At iterate    5    f=  7.40111D-01    |proj g|=  1.15138D-03

At iterate   10    f=  7.40026D-01    |proj g|=  6.72606D-03

At iterate   15    f=  7.40002D-01    |proj g|=  8.24296D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     17     21      1     0     0   9.083D-06   7.400D-01
  F =  0.74000215749271148

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
260.64072491755104
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.55212D-01    |proj g|=  2.49738D-01
 This problem is unconstrained.
At iterate    5    f=  7.03268D-01    |proj g|=  3.64541D-02

At iterate   10    f=  7.01276D-01    |proj g|=  7.89264D-04

At iterate   15    f=  7.01231D-01    |proj g|=  3.63161D-03

           * * *

Tit   = total number of iterations
```

```
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     19     22      1     0     0   2.094D-05   7.012D-01
  F =  0.70122577636247674

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
249.61186085779218
RUNNING THE L-BFGS-B CODE

           * * *

 This problem is unconstrained.
Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.49433D-01    |proj g|=  3.20682D-01

At iterate    5    f=  6.51288D-01    |proj g|=  2.42622D-02

At iterate   10    f=  6.47579D-01    |proj g|=  8.07171D-04

At iterate   15    f=  6.47559D-01    |proj g|=  1.88501D-03

At iterate   20    f=  6.47545D-01    |proj g|=  6.17491D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     20     25      1     0     0   6.175D-06   6.475D-01
  F =  0.64754534666170238

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
233.57523647833202
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.70791D-01    |proj g|=  7.92932D-02

At iterate    5    f=  7.58419D-01    |proj g|=  7.60446D-04
```

```
At iterate   10    f=  7.58418D-01    |proj g|=  7.68206D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     14     19      1     0     0   2.110D-05   7.584D-01
  F =  0.75841814884106828

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
266.82849801059893
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.51638D-01    |proj g|=  8.11355D-02
 This problem is unconstrained.
 This problem is unconstrained.
At iterate    5    f=  7.40523D-01    |proj g|=  5.84578D-03

At iterate   10    f=  7.40209D-01    |proj g|=  1.79691D-03

At iterate   15    f=  7.40176D-01    |proj g|=  6.85636D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     16     20      1     0     0   8.233D-06   7.402D-01
  F =  0.74017552396423003

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
262.6989760519813
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds
```

```
At iterate    0    f=  7.46862D-01    |proj g|=  2.42136D-01
 This problem is unconstrained.
At iterate    5    f=  7.00730D-01    |proj g|=  4.31871D-03

At iterate   10    f=  7.00131D-01    |proj g|=  1.49275D-02

At iterate   15    f=  6.99977D-01    |proj g|=  2.62481D-04

At iterate   20    f=  6.99973D-01    |proj g|=  3.69308D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     23     26      1     0     0   1.777D-05   7.000D-01
  F =  0.69997321537238288

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
251.19100036512066
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.07109D-01    |proj g|=  5.04206D-01
 This problem is unconstrained.
At iterate    5    f=  6.49655D-01    |proj g|=  2.49402D-02

At iterate   10    f=  6.47977D-01    |proj g|=  3.17687D-03

At iterate   15    f=  6.47032D-01    |proj g|=  9.15601D-03

At iterate   20    f=  6.46740D-01    |proj g|=  1.20828D-03

At iterate   25    f=  6.46736D-01    |proj g|=  8.45898D-04

At iterate   30    f=  6.46732D-01    |proj g|=  2.46977D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
```

```
    9     30     36      1     0     0   2.470D-05   6.467D-01
  F =  0.646732139052134 67

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
235.30199872151726
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.14714D-01    |proj g|=  9.67135D-02
 This problem is unconstrained.
At iterate    5    f=  7.02695D-01    |proj g|=  2.98171D-03

At iterate   10    f=  7.02568D-01    |proj g|=  2.12563D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     14     19      1     0     0   3.720D-05   7.026D-01
  F =  0.702567739977894 90

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
250.0627606325727
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.13242D-01    |proj g|=  7.00539D-02
 This problem is unconstrained.
At iterate    5    f=  7.04623D-01    |proj g|=  1.31248D-02

At iterate   10    f=  6.99517D-01    |proj g|=  2.86045D-03

At iterate   15    f=  6.99511D-01    |proj g|=  1.91004D-04

At iterate   20    f=  6.99511D-01    |proj g|=  3.35856D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
```

```
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     20     23      1     0     0   3.359D-06   6.995D-01
  F =  0.69951132055410858

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
251.0358037061805
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.28647D-01    |proj g|=  2.08554D-01
 This problem is unconstrained.
At iterate    5    f=  6.92862D-01    |proj g|=  8.29729D-03

At iterate   10    f=  6.91144D-01    |proj g|=  3.00316D-03

At iterate   15    f=  6.91114D-01    |proj g|=  2.37979D-03

At iterate   20    f=  6.91075D-01    |proj g|=  5.92340D-03

At iterate   25    f=  6.90993D-01    |proj g|=  2.29208D-04

At iterate   30    f=  6.90993D-01    |proj g|=  1.60751D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     30     32      1     0     0   1.608D-05   6.910D-01
  F =  0.69099311035071342

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
250.1736850778397
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.79681D-01    |proj g|=  6.26436D-01
 This problem is unconstrained.
At iterate    5    f=  6.50455D-01    |proj g|=  3.52407D-02

At iterate   10    f=  6.47122D-01    |proj g|=  9.39636D-03
```

```
At iterate   15    f=  6.46717D-01    |proj g|=  3.61458D-03

At iterate   20    f=  6.45895D-01    |proj g|=  8.08618D-03

At iterate   25    f=  6.45790D-01    |proj g|=  1.66289D-03

At iterate   30    f=  6.45621D-01    |proj g|=  2.67284D-03

At iterate   35    f=  6.45611D-01    |proj g|=  4.34154D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     36     41      1     0     0   2.761D-05   6.456D-01
  F =  0.64561059834485823

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
236.92516104387238
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.73709D-01    |proj g|=  9.56160D-02
 This problem is unconstrained.
At iterate    5    f=  6.55887D-01    |proj g|=  2.28750D-02
  ys=-6.130E-04  -gs= 7.641E-05 BFGS update SKIPPED

At iterate   10    f=  6.55463D-01    |proj g|=  3.30509D-03

At iterate   15    f=  6.55401D-01    |proj g|=  5.06185D-03

At iterate   20    f=  6.55320D-01    |proj g|=  1.04080D-03

At iterate   25    f=  6.55318D-01    |proj g|=  1.68003D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     25     42      1     1     0   1.680D-05   6.553D-01
```

```
  F =  0.65531788700028326

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
236.18681003209517
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.73164D-01    |proj g|=  8.01753D-02

At iterate    5    f=  6.56623D-01    |proj g|=  3.17832D-02

At iterate   10    f=  6.55597D-01    |proj g|=  1.21111D-02

At iterate   15    f=  6.54602D-01    |proj g|=  3.16283D-03

At iterate   20    f=  6.54577D-01    |proj g|=  1.44399D-02

At iterate   25    f=  6.54524D-01    |proj g|=  8.22958D-03

At iterate   30    f=  6.54516D-01    |proj g|=  9.23669D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     34     45      1     0     0   1.806D-05   6.545D-01
  F =  0.65451600366008700

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
237.91737722978922
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.96085D-01    |proj g|=  2.00676D-01
 This problem is unconstrained.
At iterate    5    f=  6.56003D-01    |proj g|=  1.12813D-02

At iterate   10    f=  6.54718D-01    |proj g|=  4.51794D-03

At iterate   15    f=  6.54600D-01    |proj g|=  2.64217D-03

At iterate   20    f=  6.54523D-01    |proj g|=  2.00055D-03
```

```
At iterate   25    f=  6.54513D-01    |proj g|=  5.14284D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     28     38      1     0     0   3.074D-05   6.545D-01
  F =  0.65451256665135782

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
239.91622239485622
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           11     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.51433D-01    |proj g|=  5.24901D-01
 This problem is unconstrained.
At iterate    5    f=  6.58361D-01    |proj g|=  2.01056D-02

At iterate   10    f=  6.49380D-01    |proj g|=  6.04783D-02
  ys=-1.100E-03  -gs= 2.422E-04 BFGS update SKIPPED

At iterate   15    f=  6.46669D-01    |proj g|=  1.12736D-02

At iterate   20    f=  6.46488D-01    |proj g|=  1.77674D-02
 Warning:  more than 10 function and gradient
   evaluations in the last line search.  Termination
   may possibly be caused by a bad search direction.
 This problem is unconstrained.
 This problem is unconstrained.
           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   11     23     50      1     1     0   3.362D-03   6.465D-01
  F =  0.64645097996622192

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
239.20752926865055
RUNNING THE L-BFGS-B CODE

           * * *
```

```
Machine precision = 2.220D-16
 N =            3     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.39722D-01    |proj g|=  2.25422D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    3      1      6      1     0     0   1.653D-05   8.397D-01
  F =  0.83972178513771145

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
288.14651980627104
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.66583D-01    |proj g|=  8.12553D-02

At iterate    5    f=  7.59050D-01    |proj g|=  1.56624D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4      8     11      1     0     0   2.888D-05   7.590D-01
  F =  0.75904608925704109

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
263.03948599036585
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds
```

```
At iterate    0    f=  7.71858D-01    |proj g|=  2.53463D-01

At iterate    5    f=  7.22043D-01    |proj g|=  4.38235D-02

 This problem is unconstrained.
At iterate   10    f=  7.18398D-01    |proj g|=  1.42527D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     12     14      1     0     0   3.897D-06   7.184D-01
  F =  0.71839844791509999

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
251.3818784994736
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.62983D-01    |proj g|=  3.52049D-01

 This problem is unconstrained.
At iterate    5    f=  6.64324D-01    |proj g|=  3.64215D-02

At iterate   10    f=  6.58270D-01    |proj g|=  7.60822D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     14     19      1     0     0   9.492D-06   6.583D-01
  F =  0.65826848740128996

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
233.1782117668334
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds
```

```
At iterate    0    f=  7.75613D-01    |proj g|=  9.07789D-02

At iterate    5    f=  7.67241D-01    |proj g|=  9.19884D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4      8     11      1     0     0   5.199D-06   7.672D-01
  F =  0.76724036531686846

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
265.7927627464678
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.63821D-01    |proj g|=  7.92854D-02
 This problem is unconstrained.
 This problem is unconstrained.
At iterate    5    f=  7.56275D-01    |proj g|=  8.89229D-03

At iterate   10    f=  7.56085D-01    |proj g|=  4.02316D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     12     15      1     0     0   8.051D-06   7.561D-01
  F =  0.75608543357786206

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
264.04470568216163
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds
```

```
At iterate    0    f=  7.63026D-01    |proj g|=  2.45423D-01
 This problem is unconstrained.
At iterate    5    f=  7.18610D-01    |proj g|=  6.10722D-03

At iterate   10    f=  7.17644D-01    |proj g|=  1.37145D-02

At iterate   15    f=  7.17422D-01    |proj g|=  6.39937D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     15     19      1     0     0   6.399D-06   7.174D-01
  F =  0.71742203841172458

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
253.05380490633945
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.11349D-01    |proj g|=  5.07697D-01
 This problem is unconstrained.
At iterate    5    f=  6.61334D-01    |proj g|=  2.74736D-02

At iterate   10    f=  6.58741D-01    |proj g|=  4.28188D-03

At iterate   15    f=  6.57538D-01    |proj g|=  1.30854D-02

At iterate   20    f=  6.57350D-01    |proj g|=  2.98453D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     22     28      1     0     0   4.931D-06   6.574D-01
  F =  0.65735036923298584

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
234.86972406228324
RUNNING THE L-BFGS-B CODE
```

```
           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.15593D-01    |proj g|=  1.11031D-01

At iterate    5    f=  7.03483D-01    |proj g|=  8.19928D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5      9     11      1     0     0   3.395D-06   7.034D-01
  F =  0.70344617037541912

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
 This problem is unconstrained.
 This problem is unconstrained.
246.3579132461408
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.15240D-01    |proj g|=  8.34969D-02

At iterate    5    f=  7.05852D-01    |proj g|=  2.41294D-02

At iterate   10    f=  6.95759D-01    |proj g|=  2.87573D-03

At iterate   15    f=  6.95750D-01    |proj g|=  5.15143D-07

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     15     18      1     0     0   5.151D-07   6.958D-01
  F =  0.69575005581227878
```

```
CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
245.77201875292567
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.38017D-01    |proj g|=  2.25560D-01

 This problem is unconstrained.
At iterate    5    f=  6.98767D-01    |proj g|=  1.93647D-02

At iterate   10    f=  6.94612D-01    |proj g|=  3.92555D-03

At iterate   15    f=  6.94493D-01    |proj g|=  1.04570D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     16     19      1     0     0   7.241D-06   6.945D-01
  F =  0.69449285732556576

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
247.3496000613901
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.65626D-01    |proj g|=  5.62549D-01
 This problem is unconstrained.
At iterate    5    f=  6.66180D-01    |proj g|=  3.55506D-02

At iterate   10    f=  6.59184D-01    |proj g|=  1.87300D-02
  ys=-1.861E-03  -gs= 1.510E-04 BFGS update SKIPPED

At iterate   15    f=  6.57643D-01    |proj g|=  3.21873D-03

At iterate   20    f=  6.57544D-01    |proj g|=  6.79516D-03
 Warning:  more than 10 function and gradient
   evaluations in the last line search.  Termination
   may possibly be caused by a bad search direction.
 This problem is unconstrained.
At iterate   25    f=  6.57351D-01    |proj g|=  2.19460D-03

           * * *
```

```
Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     25     51      1     1     0   2.195D-03   6.574D-01
  F =  0.65735114100698711

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
236.86998337834768
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.82538D-01    |proj g|=  1.32774D-01

At iterate    5    f=  6.53735D-01    |proj g|=  2.58331D-02

At iterate   10    f=  6.51634D-01    |proj g|=  3.44879D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     12     14      1     0     0   4.058D-06   6.516D-01
  F =  0.65163323894686032

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
230.94876828614508
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.82204D-01    |proj g|=  1.31381D-01

At iterate    5    f=  6.52646D-01    |proj g|=  2.48520D-02

At iterate   10    f=  6.50478D-01    |proj g|=  1.07426D-02
```

```
At iterate   15    f=  6.50207D-01    |proj g|=  3.56526D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     15     18      1     0     0   3.565D-05   6.502D-01
  F =  0.65020701050586771

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
232.46955552997156
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.04427D-01    |proj g|=  2.16766D-01
 This problem is unconstrained.
At iterate    5    f=  6.51975D-01    |proj g|=  8.64022D-02

At iterate   10    f=  6.50282D-01    |proj g|=  1.05987D-02

At iterate   15    f=  6.50214D-01    |proj g|=  2.25077D-03

At iterate   20    f=  6.50205D-01    |proj g|=  5.84978D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     20     24      1     0     0   5.850D-06   6.502D-01
  F =  0.65020494594032552

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
234.46886183594938
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds
```

```
At iterate    0    f=  8.41528D-01    |proj g|=  4.84148D-01
 This problem is unconstrained.
At iterate    5    f=  6.75736D-01    |proj g|=  5.29095D-02

At iterate   10    f=  6.53303D-01    |proj g|=  1.55482D-02

At iterate   15    f=  6.50299D-01    |proj g|=  1.68951D-02

At iterate   20    f=  6.49953D-01    |proj g|=  1.90573D-03

At iterate   25    f=  6.49945D-01    |proj g|=  3.08553D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     27     34      1     0     0   8.371D-05   6.499D-01
  F =  0.64994538572596927

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
236.38164960392567
 This problem is unconstrained.
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.38943D-01    |proj g|=  1.65595D-02

At iterate    5    f=  8.37067D-01    |proj g|=  4.83410D-02

At iterate   10    f=  8.22449D-01    |proj g|=  1.82869D-02

At iterate   15    f=  8.22152D-01    |proj g|=  5.97618D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4     18     27      1     0     0   9.826D-06   8.221D-01
  F =  0.82214781564494643
```

```
CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
284.241666056702
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.63175D-01    |proj g|=  8.18540D-02

At iterate    5    f=  7.54210D-01    |proj g|=  1.33034D-02

At iterate   10    f=  7.46167D-01    |proj g|=  4.73747D-02

At iterate   15    f=  7.44687D-01    |proj g|=  4.59527D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     18     31      1     0     0   5.890D-06   7.447D-01
  F =  0.74468644531553374

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
260.2146456260193
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.68731D-01    |proj g|=  2.53054D-01
 This problem is unconstrained.
At iterate    5    f=  7.18273D-01    |proj g|=  4.59441D-02

At iterate   10    f=  7.13882D-01    |proj g|=  1.67849D-02

At iterate   15    f=  7.07112D-01    |proj g|=  6.00352D-02

At iterate   20    f=  7.05468D-01    |proj g|=  5.55484D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
```

```
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     23     27      1     0     0   5.800D-06   7.055D-01
  F =  0.70546812991739449

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
249.03729165224456
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.57659D-01    |proj g|=  3.40248D-01
 This problem is unconstrained.
At iterate    5    f=  6.57902D-01    |proj g|=  3.92932D-02

At iterate   10    f=  6.54013D-01    |proj g|=  2.61711D-03

At iterate   15    f=  6.52963D-01    |proj g|=  1.49874D-02

At iterate   20    f=  6.52496D-01    |proj g|=  5.91874D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     23     26      1     0     0   1.301D-05   6.525D-01
  F =  0.65249602484735647

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
233.23866434871178
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.74768D-01    |proj g|=  9.02952D-02

At iterate    5    f=  7.63502D-01    |proj g|=  1.85802D-02
 This problem is unconstrained.
 This problem is unconstrained.
At iterate   10    f=  7.55961D-01    |proj g|=  1.64044D-02

At iterate   15    f=  7.55720D-01    |proj g|=  4.11658D-05
```

```
           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     16     25      1     0     0   1.551D-06   7.557D-01
  F =  0.75572043776861175

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
263.92206709025356
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.63138D-01    |proj g|=  7.83606D-02

At iterate    5    f=  7.54235D-01    |proj g|=  1.23743D-02

At iterate   10    f=  7.49421D-01    |proj g|=  6.87273D-02

At iterate   15    f=  7.45652D-01    |proj g|=  3.38878D-03

At iterate   20    f=  7.45624D-01    |proj g|=  4.72080D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     20     26      1     0     0   4.721D-06   7.456D-01
  F =  0.74562426918967417

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
262.5297544477305
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.59731D-01    |proj g|=  2.45036D-01
```

```
 This problem is unconstrained.
At iterate    5    f=  7.14658D-01    |proj g|=  5.89648D-03

At iterate   10    f=  7.10686D-01    |proj g|=  5.58666D-02

At iterate   15    f=  7.06004D-01    |proj g|=  4.15584D-02

At iterate   20    f=  7.03970D-01    |proj g|=  4.38439D-03

At iterate   25    f=  7.03913D-01    |proj g|=  1.05189D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     25     28      1     0     0   1.052D-05   7.039D-01
  F =  0.70391315617984040

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
250.5148204764264
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.06508D-01    |proj g|=  4.96754D-01
 This problem is unconstrained.
At iterate    5    f=  6.56587D-01    |proj g|=  2.57727D-02

At iterate   10    f=  6.54351D-01    |proj g|=  5.40956D-03

At iterate   15    f=  6.52548D-01    |proj g|=  1.06053D-02

At iterate   20    f=  6.52308D-01    |proj g|=  5.17201D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     21     26      1     0     0   2.337D-05   6.523D-01
  F =  0.65230814271602477

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
```

```
235.17553595258434
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.15290D-01    |proj g|=  1.10565D-01

At iterate    5    f=  7.02491D-01    |proj g|=  3.37413D-03

At iterate   10    f=  7.01136D-01    |proj g|=  3.56698D-02
 This problem is unconstrained.
At iterate   15    f=  6.98404D-01    |proj g|=  7.90862D-03

At iterate   20    f=  6.98306D-01    |proj g|=  3.96454D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     20     27      1     0     0   3.965D-06   6.983D-01
  F =  0.69830583509314048

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
246.6307605912952
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.14781D-01    |proj g|=  8.31139D-02
 This problem is unconstrained.
At iterate    5    f=  7.05306D-01    |proj g|=  2.30665D-02

At iterate   10    f=  6.94733D-01    |proj g|=  9.78098D-03

At iterate   15    f=  6.94652D-01    |proj g|=  2.74866D-04

At iterate   20    f=  6.94636D-01    |proj g|=  1.65451D-03

At iterate   25    f=  6.94633D-01    |proj g|=  3.31173D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
```

```
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     25     28      1     0     0   3.312D-05   6.946D-01
  F =  0.69463317305464678

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
247.39674614636132
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.37789D-01    |proj g|=  2.24506D-01
 This problem is unconstrained.
At iterate    5    f=  6.98278D-01    |proj g|=  1.62491D-02

At iterate   10    f=  6.93389D-01    |proj g|=  2.83444D-03

At iterate   15    f=  6.93347D-01    |proj g|=  3.22731D-04

At iterate   20    f=  6.93346D-01    |proj g|=  1.35695D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     24     28      1     0     0   2.067D-05   6.933D-01
  F =  0.69334634539431816

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
248.96437205249092
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.61009D-01    |proj g|=  5.57499D-01
 This problem is unconstrained.
At iterate    5    f=  6.59954D-01    |proj g|=  2.63434D-02

At iterate   10    f=  6.53683D-01    |proj g|=  1.83561D-02

At iterate   15    f=  6.53192D-01    |proj g|=  3.63585D-03
```

```
At iterate   20    f=  6.52496D-01    |proj g|=  1.79007D-02

At iterate   25    f=  6.52189D-01    |proj g|=  4.50870D-03

At iterate   30    f=  6.51937D-01    |proj g|=  1.34746D-03

At iterate   35    f=  6.51894D-01    |proj g|=  2.91388D-03

At iterate   40    f=  6.51669D-01    |proj g|=  3.69745D-03

At iterate   45    f=  6.51179D-01    |proj g|=  1.31881D-02

At iterate   50    f=  6.50577D-01    |proj g|=  4.94050D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     50     64      1     0     0   4.941D-03   6.506D-01
  F =  0.65057745041272597

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
236.59402333867592
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.81200D-01    |proj g|=  1.25233D-01
 This problem is unconstrained.
At iterate    5    f=  6.51689D-01    |proj g|=  1.41215D-02

At iterate   10    f=  6.51071D-01    |proj g|=  1.76070D-04

At iterate   15    f=  6.51071D-01    |proj g|=  2.52155D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     19     22      1     0     0   3.796D-06   6.511D-01
  F =  0.65107062824359707
```

```
CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
232.7597310898486
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.80823D-01    |proj g|=  1.24561D-01
 This problem is unconstrained.
At iterate    5    f=  6.51226D-01    |proj g|=  1.11029D-02

At iterate   10    f=  6.49932D-01    |proj g|=  1.20147D-02

At iterate   15    f=  6.49856D-01    |proj g|=  6.13564D-04

At iterate   20    f=  6.49851D-01    |proj g|=  8.93703D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     22     26      1     0     0   1.481D-05   6.499D-01
  F =  0.64985080575643883

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
234.34987073416343
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.03130D-01    |proj g|=  2.15347D-01
 This problem is unconstrained.
At iterate    5    f=  6.51244D-01    |proj g|=  1.47875D-02

At iterate   10    f=  6.49910D-01    |proj g|=  2.45790D-03

At iterate   15    f=  6.49856D-01    |proj g|=  1.86553D-03

At iterate   20    f=  6.49852D-01    |proj g|=  2.86055D-04

At iterate   25    f=  6.49850D-01    |proj g|=  1.69987D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
```

```
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     27     31      1     0     0   1.406D-05   6.499D-01
  F =  0.64985022259640401

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
236.34967479239174
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.40749D-01    |proj g|=  4.82518D-01
 This problem is unconstrained.
At iterate    5    f=  6.73058D-01    |proj g|=  5.69232D-02

At iterate   10    f=  6.53101D-01    |proj g|=  1.23879D-02

At iterate   15    f=  6.49916D-01    |proj g|=  1.13013D-02

At iterate   20    f=  6.49632D-01    |proj g|=  1.91665D-03

At iterate   25    f=  6.49606D-01    |proj g|=  2.69844D-03

At iterate   30    f=  6.49588D-01    |proj g|=  7.86912D-05

At iterate   35    f=  6.49588D-01    |proj g|=  5.18690D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     38     44      1     0     0   8.734D-06   6.496D-01
  F =  0.64958834620366657

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
238.26168432443197
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds
```

```
At iterate    0    f=  8.24388D-01    |proj g|=  5.00447D-02

At iterate    5    f=  8.21483D-01    |proj g|=  3.09802D-02

At iterate   10    f=  8.20626D-01    |proj g|=  2.57239D-02

At iterate   15    f=  8.20345D-01    |proj g|=  1.29488D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     16     19      1     0     0   1.686D-05   8.203D-01
  F =  0.82034529412787427

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
 This problem is unconstrained.
 This problem is unconstrained.
285.63601882696577
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.49758D-01    |proj g|=  7.91825D-02

At iterate    5    f=  7.39779D-01    |proj g|=  9.23093D-03

At iterate   10    f=  7.39193D-01    |proj g|=  1.12480D-02

At iterate   15    f=  7.39132D-01    |proj g|=  3.21685D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     15     19      1     0     0   3.217D-05   7.391D-01
  F =  0.73913221703009446

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
260.34842492211175
 This problem is unconstrained.
```

```
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.58275D-01    |proj g|=  2.59501D-01

At iterate    5    f=  7.04519D-01    |proj g|=  4.47921D-02

At iterate   10    f=  7.01084D-01    |proj g|=  3.90020D-03

At iterate   15    f=  7.00800D-01    |proj g|=  6.74135D-03

At iterate   20    f=  7.00767D-01    |proj g|=  4.31987D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     23     27      1     0     0   2.328D-05   7.008D-01
  F =  0.70076663227526459

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
249.45758844448892
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.47078D-01    |proj g|=  3.45769D-01

At iterate    5    f=  6.48813D-01    |proj g|=  3.79286D-02

At iterate   10    f=  6.45322D-01    |proj g|=  3.53179D-03

At iterate   15    f=  6.44973D-01    |proj g|=  4.38942D-03

At iterate   20    f=  6.44958D-01    |proj g|=  1.46297D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
```

```
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     23     27      1     0     0   6.977D-06   6.450D-01
  F =  0.64495784549293156

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
232.705836085625
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.63511D-01    |proj g|=  9.02804D-02

At iterate    5    f=  7.51681D-01    |proj g|=  7.11154D-03
 This problem is unconstrained.
 This problem is unconstrained.
At iterate   10    f=  7.50994D-01    |proj g|=  4.97314D-03

At iterate   15    f=  7.50964D-01    |proj g|=  2.78343D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     15     20      1     0     0   2.783D-05   7.510D-01
  F =  0.75096397143545568

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
264.3238944023131
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.49716D-01    |proj g|=  7.57833D-02

At iterate    5    f=  7.39877D-01    |proj g|=  1.05299D-02

At iterate   10    f=  7.39417D-01    |proj g|=  5.64913D-03

At iterate   15    f=  7.39293D-01    |proj g|=  1.16530D-03

           * * *
```

```
Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     19     23      1     0     0   1.039D-05   7.393D-01
  F =  0.73929139021391099

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
262.4019071118741
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.49553D-01    |proj g|=  2.54444D-01
 This problem is unconstrained.
At iterate    5    f=  7.01525D-01    |proj g|=  1.12274D-02

At iterate   10    f=  7.00398D-01    |proj g|=  5.95245D-03

At iterate   15    f=  6.99464D-01    |proj g|=  3.83765D-03

At iterate   20    f=  6.99448D-01    |proj g|=  5.73119D-04

At iterate   25    f=  6.99447D-01    |proj g|=  1.77729D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     27     31      1     0     0   1.057D-05   6.994D-01
  F =  0.69944655688583646

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
251.01404311364104
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.97347D-01    |proj g|=  5.08364D-01
```

```
 This problem is unconstrained.
At iterate    5    f=  6.47394D-01    |proj g|=  2.37179D-02

At iterate   10    f=  6.45622D-01    |proj g|=  3.54850D-03

At iterate   15    f=  6.44978D-01    |proj g|=  3.88027D-03

At iterate   20    f=  6.44897D-01    |proj g|=  5.88066D-03

At iterate   25    f=  6.44706D-01    |proj g|=  1.04490D-02

At iterate   30    f=  6.44666D-01    |proj g|=  5.88094D-04

At iterate   35    f=  6.44666D-01    |proj g|=  1.62026D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     35     41      1     0     0   1.620D-05   6.447D-01
  F =  0.64466554500882312

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
234.60762312296455
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.08043D-01    |proj g|=  1.09012D-01

At iterate    5    f=  6.95345D-01    |proj g|=  5.03333D-03

At iterate   10    f=  6.94795D-01    |proj g|=  1.97093D-03
 This problem is unconstrained.
At iterate   15    f=  6.94773D-01    |proj g|=  2.70074D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     18     22      1     0     0   8.297D-06   6.948D-01
  F =  0.69477278292316724
```

```
CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
247.44365506218418
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.06944D-01    |proj g|=  8.09483D-02

At iterate    5    f=  6.98096D-01    |proj g|=  1.91829D-02
 This problem is unconstrained.
At iterate   10    f=  6.90548D-01    |proj g|=  1.31731D-02

At iterate   15    f=  6.89314D-01    |proj g|=  3.01673D-04

At iterate   20    f=  6.89314D-01    |proj g|=  2.95797D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     24     27      1     0     0   6.720D-06   6.893D-01
  F =  0.68931413564018218

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
247.6095495751012
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.28357D-01    |proj g|=  2.24517D-01
 This problem is unconstrained.
At iterate    5    f=  6.89698D-01    |proj g|=  1.10513D-02

At iterate   10    f=  6.85736D-01    |proj g|=  4.46536D-03

At iterate   15    f=  6.85654D-01    |proj g|=  1.52684D-03

At iterate   20    f=  6.85568D-01    |proj g|=  9.93077D-03

At iterate   25    f=  6.85496D-01    |proj g|=  3.74918D-03

At iterate   30    f=  6.85491D-01    |proj g|=  8.42333D-05

           * * *
```

```
Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     33     40      1     0     0   1.795D-05   6.855D-01
  F =  0.68549066358329314

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
248.3248629639865
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.61765D-01    |proj g|=  6.05707D-01
 This problem is unconstrained.
At iterate    5    f=  6.50113D-01    |proj g|=  2.64243D-02

At iterate   10    f=  6.46489D-01    |proj g|=  7.12553D-03

At iterate   15    f=  6.44866D-01    |proj g|=  1.18430D-02

At iterate   20    f=  6.44720D-01    |proj g|=  2.39770D-03

At iterate   25    f=  6.44688D-01    |proj g|=  7.86102D-04

At iterate   30    f=  6.44311D-01    |proj g|=  2.11484D-02

At iterate   35    f=  6.42643D-01    |proj g|=  8.04453D-03

At iterate   40    f=  6.42450D-01    |proj g|=  3.13687D-03

At iterate   45    f=  6.42439D-01    |proj g|=  4.55196D-04

At iterate   50    f=  6.42439D-01    |proj g|=  4.36985D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     50     61      1     0     0   4.370D-05   6.424D-01
  F =  0.64243925850723671

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
235.85959085843152
```

```
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.71963D-01    |proj g|=  1.07188D-01

At iterate    5    f=  6.48363D-01    |proj g|=  2.60401D-02
 This problem is unconstrained.
At iterate   10    f=  6.46892D-01    |proj g|=  9.12600D-03

At iterate   15    f=  6.46637D-01    |proj g|=  8.12665D-03

At iterate   20    f=  6.46555D-01    |proj g|=  2.15977D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     24     27      1     0     0   2.811D-06   6.466D-01
  F =  0.64655458988796544

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
233.24234220235638
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.71461D-01    |proj g|=  1.05003D-01

At iterate    5    f=  6.50053D-01    |proj g|=  7.29340D-01

At iterate   10    f=  6.49013D-01    |proj g|=  1.55569D-01

At iterate   15    f=  6.48801D-01    |proj g|=  3.49302D-01

At iterate   20    f=  6.48544D-01    |proj g|=  4.32593D-02

At iterate   25    f=  6.48532D-01    |proj g|=  5.71740D-02

At iterate   30    f=  6.48462D-01    |proj g|=  2.64571D-02

At iterate   35    f=  6.48336D-01    |proj g|=  1.05043D-02

At iterate   40    f=  6.48137D-01    |proj g|=  8.75492D-02
```

```
At iterate   45    f=  6.48046D-01    |proj g|=  4.90163D-03

At iterate   50    f=  6.47407D-01    |proj g|=  2.21626D-01

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     50     62      1     0     0   2.216D-01   6.474D-01
  F =  0.64740676094543037

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
235.52867167766462
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.94210D-01    |proj g|=  2.15509D-01
 This problem is unconstrained.
At iterate    5    f=  6.47830D-01    |proj g|=  1.66857D-02

At iterate   10    f=  6.45767D-01    |proj g|=  9.39967D-03

At iterate   15    f=  6.45469D-01    |proj g|=  9.96037D-03

At iterate   20    f=  6.45409D-01    |proj g|=  2.47431D-04

At iterate   25    f=  6.45409D-01    |proj g|=  2.76892D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     26     31      1     0     0   1.247D-05   6.454D-01
  F =  0.64540911002917867

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
236.85746096980404
RUNNING THE L-BFGS-B CODE

           * * *
```

```
Machine precision = 2.220D-16
 N =           11     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.35847D-01    |proj g|=  4.98082D-01
 This problem is unconstrained.
At iterate    5    f=  6.62143D-01    |proj g|=  4.52857D-02

At iterate   10    f=  6.49629D-01    |proj g|=  2.62182D-02

At iterate   15    f=  6.42541D-01    |proj g|=  6.46539D-03

At iterate   20    f=  6.41700D-01    |proj g|=  5.63180D-03

At iterate   25    f=  6.41650D-01    |proj g|=  6.19746D-04

At iterate   30    f=  6.41649D-01    |proj g|=  1.35095D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   11     33     39      1     0     0   1.032D-04   6.416D-01
  F =  0.64164914636174297

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
237.59411317754564
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.17524D-01    |proj g|=  4.37851D-01

At iterate    5    f=  8.08520D-01    |proj g|=  4.07463D-02

At iterate   10    f=  8.07016D-01    |proj g|=  1.09598D-02

At iterate   15    f=  8.05292D-01    |proj g|=  1.57632D-02

At iterate   20    f=  8.04984D-01    |proj g|=  6.34353D-03

At iterate   25    f=  8.04930D-01    |proj g|=  2.05200D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
```

```
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     27     35      1     0     0   3.149D-05   8.049D-01
  F =  0.80492964478337348

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
282.4563606472135
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.51725D-01    |proj g|=  6.54266D-01
 This problem is unconstrained.
 This problem is unconstrained.
At iterate    5    f=  7.30600D-01    |proj g|=  5.08173D-02

At iterate   10    f=  7.27582D-01    |proj g|=  3.52557D-01

At iterate   15    f=  7.24187D-01    |proj g|=  8.25292D-02

At iterate   20    f=  7.22583D-01    |proj g|=  5.78572D-03
 Bad direction in the line search;
   refresh the lbfgs memory and restart the iteration.

 Warning:  more than 10 function and gradient
   evaluations in the last line search.  Termination
   may possibly be caused by a bad search direction.
 This problem is unconstrained.
At iterate   25    f=  7.22562D-01    |proj g|=  2.62104D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     25     66      2     0     0   2.621D-05   7.226D-01
  F =  0.72256181326340552

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
256.78076925650424
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds
```

```
At iterate    0    f=  7.52046D-01    |proj g|=  2.57836D-01

At iterate    5    f=  7.05361D-01    |proj g|=  2.03913D-01

At iterate   10    f=  6.88894D-01    |proj g|=  2.42241D-02

At iterate   15    f=  6.84336D-01    |proj g|=  3.63482D-02

At iterate   20    f=  6.75359D-01    |proj g|=  5.67118D-02

At iterate   25    f=  6.73034D-01    |proj g|=  8.96038D-03

At iterate   30    f=  6.72932D-01    |proj g|=  5.55886D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     33     39      1     0     0   8.175D-06   6.729D-01
  F =  0.67293180935326558

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
242.10508794269722
RUNNING THE L-BFGS-B CODE

 This problem is unconstrained.
           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.94638D-01    |proj g|=  1.70528D+00

At iterate    5    f=  6.56616D-01    |proj g|=  2.63793D-01

At iterate   10    f=  6.41457D-01    |proj g|=  7.16469D-02

At iterate   15    f=  6.36303D-01    |proj g|=  4.89783D-02

At iterate   20    f=  6.33765D-01    |proj g|=  6.14359D-02

At iterate   25    f=  6.33677D-01    |proj g|=  7.14105D-04

At iterate   30    f=  6.33676D-01    |proj g|=  9.78957D-04

At iterate   35    f=  6.33676D-01    |proj g|=  2.04526D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
```

```
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     38     45      1     0     0   9.103D-05   6.337D-01
  F =  0.63367620848451134

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
230.9152060507958
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.70033D-01    |proj g|=  5.49979D-01

At iterate    5    f=  7.47482D-01    |proj g|=  3.52716D-02

At iterate   10    f=  7.45551D-01    |proj g|=  4.95700D-02

At iterate   15    f=  7.39571D-01    |proj g|=  1.52188D-02
 This problem is unconstrained.
At iterate   20    f=  7.34092D-01    |proj g|=  5.43128D-02

At iterate   25    f=  7.29363D-01    |proj g|=  1.65265D-02

At iterate   30    f=  7.29322D-01    |proj g|=  1.10048D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     32     43      1     0     0   1.331D-05   7.293D-01
  F =  0.72932151762723796

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
259.05202992275196
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.56582D-01    |proj g|=  6.53619D-01
 This problem is unconstrained.
At iterate    5    f=  7.34620D-01    |proj g|=  2.58577D-02
```

```
At iterate   10    f=  7.31043D-01    |proj g|=  6.81083D-02

At iterate   15    f=  7.25540D-01    |proj g|=  1.49251D-02

At iterate   20    f=  7.21921D-01    |proj g|=  6.43004D-02

At iterate   25    f=  7.14178D-01    |proj g|=  2.01877D-02

At iterate   30    f=  7.11905D-01    |proj g|=  4.70813D-03

At iterate   35    f=  7.11896D-01    |proj g|=  3.29662D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     35     47      1     0     0   3.297D-05   7.119D-01
  F =  0.71189632451044249

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
255.19716503550868
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.44000D-01    |proj g|=  3.04722D-01
 This problem is unconstrained.
At iterate    5    f=  6.93822D-01    |proj g|=  4.71814D-02

At iterate   10    f=  6.88518D-01    |proj g|=  4.36336D-02

At iterate   15    f=  6.84472D-01    |proj g|=  3.04689D-02

At iterate   20    f=  6.72399D-01    |proj g|=  4.74643D-02

At iterate   25    f=  6.71653D-01    |proj g|=  1.83537D-03

At iterate   30    f=  6.71652D-01    |proj g|=  6.80350D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *
```

```
   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     34     43      1     0     0   2.385D-05   6.717D-01
  F =  0.67165134188353459

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
243.6748508728676
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.45082D-01    |proj g|=  2.07458D+00
 This problem is unconstrained.
At iterate    5    f=  6.48959D-01    |proj g|=  2.33925D-01

At iterate   10    f=  6.38806D-01    |proj g|=  1.69271D-01

At iterate   15    f=  6.34626D-01    |proj g|=  3.76141D-02

At iterate   20    f=  6.33992D-01    |proj g|=  1.71153D-02

At iterate   25    f=  6.33246D-01    |proj g|=  7.46104D-02

At iterate   30    f=  6.32481D-01    |proj g|=  6.99241D-03

At iterate   35    f=  6.32466D-01    |proj g|=  1.94727D-03

At iterate   40    f=  6.32465D-01    |proj g|=  2.08272D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     42     49      1     0     0   1.374D-04   6.325D-01
  F =  0.63246496141146369

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
232.5082270342518
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.21760D-01    |proj g|=  5.76916D-01

At iterate    5    f=  6.92341D-01    |proj g|=  5.88817D-02
 This problem is unconstrained.
```

```
At iterate   10    f=  6.87633D-01    |proj g|=  4.65714D-02

At iterate   15    f=  6.82089D-01    |proj g|=  1.29591D-02

At iterate   20    f=  6.73072D-01    |proj g|=  7.29658D-02

At iterate   25    f=  6.67732D-01    |proj g|=  2.26180D-02

At iterate   30    f=  6.67082D-01    |proj g|=  3.15431D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     34     42      1     0     0   5.773D-05   6.671D-01
  F =  0.66708232063934769

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
240.13965973482084
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.21966D-01    |proj g|=  6.14540D-01

At iterate    5    f=  6.96701D-01    |proj g|=  2.72145D-02
 This problem is unconstrained.
At iterate   10    f=  6.86464D-01    |proj g|=  2.89616D-02

At iterate   15    f=  6.77456D-01    |proj g|=  1.65005D-02

At iterate   20    f=  6.70685D-01    |proj g|=  3.16023D-02

At iterate   25    f=  6.68009D-01    |proj g|=  1.80525D-02

At iterate   30    f=  6.64694D-01    |proj g|=  2.03787D-02

At iterate   35    f=  6.64399D-01    |proj g|=  2.13054D-03

At iterate   40    f=  6.64395D-01    |proj g|=  8.02996D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value
```

```
           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     44     55      1     0     0   5.787D-06   6.644D-01
  F =  0.66439487141070586

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
241.23667679399716
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.29185D-01    |proj g|=  3.69423D-01
 This problem is unconstrained.
At iterate    5    f=  6.83587D-01    |proj g|=  3.92640D-02

At iterate   10    f=  6.74108D-01    |proj g|=  5.24125D-02

At iterate   15    f=  6.64656D-01    |proj g|=  4.58713D-02

At iterate   20    f=  6.57451D-01    |proj g|=  4.62172D-02

At iterate   25    f=  6.53701D-01    |proj g|=  4.65571D-02

At iterate   30    f=  6.50071D-01    |proj g|=  1.60377D-02

At iterate   35    f=  6.49963D-01    |proj g|=  2.01298D-03

At iterate   40    f=  6.49957D-01    |proj g|=  3.46575D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     43     53      1     0     0   1.405D-05   6.500D-01
  F =  0.64995742105777177

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
238.38569347541133
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           11     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.97581D-01    |proj g|=  2.36935D+00
```

```
At iterate    5    f=  6.56285D-01    |proj g|=  1.58625D-01

At iterate   10    f=  6.37608D-01    |proj g|=  2.50380D-02

At iterate   15    f=  6.30630D-01    |proj g|=  1.76606D-02

At iterate   20    f=  6.24395D-01    |proj g|=  5.75407D-02

At iterate   25    f=  6.20581D-01    |proj g|=  2.22518D-02

At iterate   30    f=  6.12826D-01    |proj g|=  6.55121D-02

At iterate   35    f=  6.07742D-01    |proj g|=  2.52122D-02

At iterate   40    f=  6.05760D-01    |proj g|=  2.06324D-02

At iterate   45    f=  6.04960D-01    |proj g|=  1.36755D-03

At iterate   50    f=  6.04954D-01    |proj g|=  1.95574D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   11     50     62      1     0     0   1.956D-04   6.050D-01
  F =  0.60495385060557627

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
225.26449380347364
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.88847D-01    |proj g|=  4.66988D-01
 This problem is unconstrained.
At iterate    5    f=  6.51794D-01    |proj g|=  2.20176D-01

At iterate   10    f=  6.39186D-01    |proj g|=  9.20231D-02

At iterate   15    f=  6.35070D-01    |proj g|=  2.34518D-02

At iterate   20    f=  6.23216D-01    |proj g|=  5.92061D-02

At iterate   25    f=  6.17183D-01    |proj g|=  4.93565D-03

At iterate   30    f=  6.17166D-01    |proj g|=  1.81272D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
```

```
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     34     59      1     0     0   1.797D-04   6.172D-01
  F =  0.61716576684230184

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
225.3676976590134
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.89794D-01    |proj g|=  4.99645D-01
 This problem is unconstrained.
At iterate    5    f=  6.54270D-01    |proj g|=  2.47238D-01

At iterate   10    f=  6.39522D-01    |proj g|=  1.01073D-01

At iterate   15    f=  6.35081D-01    |proj g|=  1.38614D-02

At iterate   20    f=  6.26231D-01    |proj g|=  2.36545D-01

At iterate   25    f=  6.19613D-01    |proj g|=  4.86854D-01

At iterate   30    f=  6.18385D-01    |proj g|=  2.63244D-01

At iterate   35    f=  6.16716D-01    |proj g|=  1.21970D-02

At iterate   40    f=  6.16622D-01    |proj g|=  4.00369D-02

At iterate   45    f=  6.16444D-01    |proj g|=  3.36727D-02

At iterate   50    f=  6.16393D-01    |proj g|=  3.11292D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     50     70      1     0     0   3.113D-03   6.164D-01
  F =  0.61639265383326702

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
227.10793168797773
RUNNING THE L-BFGS-B CODE
```

```
           * * *

Machine precision = 2.220D-16
 N =           11     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.02016D-01    |proj g|=  2.53779D-01
 This problem is unconstrained.
At iterate    5    f=  6.48968D-01    |proj g|=  5.91398D-02

At iterate   10    f=  6.34852D-01    |proj g|=  1.45475D-02

At iterate   15    f=  6.29883D-01    |proj g|=  7.43794D-02

At iterate   20    f=  6.22194D-01    |proj g|=  3.57969D-02

At iterate   25    f=  6.17904D-01    |proj g|=  6.02018D-01

At iterate   30    f=  6.17119D-01    |proj g|=  9.66752D-02

At iterate   35    f=  6.15821D-01    |proj g|=  2.08873D-02

At iterate   40    f=  6.15372D-01    |proj g|=  1.62933D-01

At iterate   45    f=  6.14826D-01    |proj g|=  3.16350D-02

At iterate   50    f=  6.13925D-01    |proj g|=  4.37196D-01

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   11     50     70      1     0     0   4.372D-01   6.139D-01
  F =  0.61392492747753580

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
228.27877563245204
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           12     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.81462D-01    |proj g|=  2.04929D+00

At iterate    5    f=  6.65944D-01    |proj g|=  7.01318D-02

At iterate   10    f=  6.35624D-01    |proj g|=  7.08545D-02

At iterate   15    f=  6.26292D-01    |proj g|=  2.60788D-02
```

```
At iterate   20    f=  6.17495D-01    |proj g|=  5.52551D-02

At iterate   25    f=  6.12429D-01    |proj g|=  2.08574D-02

At iterate   30    f=  6.06532D-01    |proj g|=  5.63287D-01

At iterate   35    f=  6.06244D-01    |proj g|=  7.45172D-02

At iterate   40    f=  6.05922D-01    |proj g|=  1.15508D-01

At iterate   45    f=  6.05535D-01    |proj g|=  9.66310D-02

At iterate   50    f=  6.05437D-01    |proj g|=  8.05429D-02

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   12     50     71      1     0     0   8.054D-02   6.054D-01
  F =  0.60543685552474591

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
227.42678345631464
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.36832D-01    |proj g|=  2.31877D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4      1      6      1     0     0   2.069D-05   8.368D-01
  F =  0.83683220573141526

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
 This problem is unconstrained.
 This problem is unconstrained.
 This problem is unconstrained.
289.1756211257555
RUNNING THE L-BFGS-B CODE
```

```
           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.66204D-01    |proj g|=  8.11612D-02

At iterate    5    f=  7.58354D-01    |proj g|=  5.32639D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5      9     12      1     0     0   1.054D-05   7.583D-01
  F =  0.75833409940331875

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
264.8002573995151
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.71904D-01    |proj g|=  2.54881D-01

At iterate    5    f=  7.21340D-01    |proj g|=  4.32286D-02

At iterate   10    f=  7.17788D-01    |proj g|=  6.33726D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     14     22      1     0     0   1.422D-05   7.178D-01
  F =  0.71776447064874760

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
253.16886213797918
RUNNING THE L-BFGS-B CODE

           * * *
```

```
Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.60970D-01    |proj g|=  3.37825D-01
 This problem is unconstrained.
At iterate    5    f=  6.62455D-01    |proj g|=  3.44878D-02

At iterate   10    f=  6.57866D-01    |proj g|=  3.00699D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     14     22      1     0     0   1.146D-05   6.579D-01
  F =  0.65785214819365501

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
235.03832179306806
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.72570D-01    |proj g|=  9.10085D-02

At iterate    5    f=  7.63905D-01    |proj g|=  7.73677D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5      9     13      1     0     0   4.495D-06   7.639D-01
  F =  0.76387189882128326

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
266.6609580039512
 This problem is unconstrained.
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE
```

```
           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.60776D-01    |proj g|=  8.00199D-02

At iterate    5    f=  7.52950D-01    |proj g|=  2.04231D-02

At iterate   10    f=  7.52673D-01    |proj g|=  4.01627D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     14     17      1     0     0   4.024D-06   7.527D-01
  F =  0.75267007588293589

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
264.89714549666644
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.63167D-01    |proj g|=  2.47685D-01
 This problem is unconstrained.
At iterate    5    f=  7.18242D-01    |proj g|=  9.63779D-03

At iterate   10    f=  7.17467D-01    |proj g|=  7.54015D-03

At iterate   15    f=  7.16811D-01    |proj g|=  8.11962D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     18     23      1     0     0   5.921D-06   7.168D-01
  F =  0.71681055611114153

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
```

```
254.84834685334354
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.09471D-01    |proj g|=  4.93473D-01
 This problem is unconstrained.
At iterate    5    f=  6.60263D-01    |proj g|=  2.18686D-02

At iterate   10    f=  6.58268D-01    |proj g|=  4.76904D-03

At iterate   15    f=  6.57643D-01    |proj g|=  9.54147D-03

At iterate   20    f=  6.57078D-01    |proj g|=  9.22083D-04

At iterate   25    f=  6.57076D-01    |proj g|=  4.22855D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     25     31      1     0     0   4.229D-06   6.571D-01
  F =  0.65707613309015900

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
236.77758071829342
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.13099D-01    |proj g|=  1.11413D-01

At iterate    5    f=  7.00730D-01    |proj g|=  5.48413D-03

At iterate   10    f=  7.00663D-01    |proj g|=  1.15424D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value
```

```
           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     10     12      1     0     0   1.154D-06   7.007D-01
  F =  0.70066340869459243

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
247.42290532138304
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.12546D-01    |proj g|=  8.38524D-02
 This problem is unconstrained.
 This problem is unconstrained.
At iterate    5    f=  7.03417D-01    |proj g|=  2.72964D-02

At iterate   10    f=  6.93005D-01    |proj g|=  9.88843D-03

At iterate   15    f=  6.92930D-01    |proj g|=  9.13512D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     17     20      1     0     0   7.534D-06   6.929D-01
  F =  0.69292971567359507

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
246.82438446632796
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.35558D-01    |proj g|=  2.25822D-01

 This problem is unconstrained.
At iterate    5    f=  6.96364D-01    |proj g|=  2.01195D-02

At iterate   10    f=  6.92077D-01    |proj g|=  1.14797D-02

At iterate   15    f=  6.91716D-01    |proj g|=  2.17269D-03

           * * *

Tit   = total number of iterations
```

```
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     19     22      1     0     0   3.008D-06   6.917D-01
  F =  0.69170952131778674

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
248.41439916277633
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.65982D-01    |proj g|=  5.55489D-01
 This problem is unconstrained.
At iterate    5    f=  6.64922D-01    |proj g|=  3.06650D-02

At iterate   10    f=  6.58513D-01    |proj g|=  1.82902D-02
  ys=-2.911E-03  -gs= 1.169E-04 BFGS update SKIPPED

At iterate   15    f=  6.57355D-01    |proj g|=  2.73451D-03

At iterate   20    f=  6.57296D-01    |proj g|=  4.63503D-03

At iterate   25    f=  6.57082D-01    |proj g|=  9.51559D-03

At iterate   30    f=  6.57076D-01    |proj g|=  3.27509D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     32     48      1     1     0   2.020D-04   6.571D-01
  F =  0.65707613524266639

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
238.77758144153592
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds
```

```
At iterate    0    f=  6.78205D-01    |proj g|=  1.29679D-01
 This problem is unconstrained.
At iterate    5    f=  6.49560D-01    |proj g|=  2.19614D-02

At iterate   10    f=  6.47891D-01    |proj g|=  1.50907D-03

At iterate   15    f=  6.47877D-01    |proj g|=  1.62045D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     15     17      1     0     0   1.620D-06   6.479D-01
  F =  0.64787734049869050

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
231.68678640756
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.77816D-01    |proj g|=  1.28141D-01

At iterate    5    f=  6.48724D-01    |proj g|=  1.83273D-02
 This problem is unconstrained.
At iterate   10    f=  6.46730D-01    |proj g|=  6.05589D-03

At iterate   15    f=  6.46443D-01    |proj g|=  2.55280D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     17     21      1     0     0   1.225D-05   6.464D-01
  F =  0.64644266216655166

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
233.20473448796136
RUNNING THE L-BFGS-B CODE

           * * *
```

```
Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.00038D-01    |proj g|=  2.16709D-01
 This problem is unconstrained.
At iterate    5    f=  6.49361D-01    |proj g|=  2.21168D-02

At iterate   10    f=  6.46553D-01    |proj g|=  3.97619D-03

At iterate   15    f=  6.46450D-01    |proj g|=  1.85887D-03

At iterate   20    f=  6.46442D-01    |proj g|=  7.05125D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     24     29      1     0     0   1.161D-05   6.464D-01
  F =  0.64644148386457678

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
235.20433857849778
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.36508D-01    |proj g|=  4.83725D-01
 This problem is unconstrained.
At iterate    5    f=  6.69848D-01    |proj g|=  3.55075D-02

At iterate   10    f=  6.50489D-01    |proj g|=  3.81441D-02

At iterate   15    f=  6.47208D-01    |proj g|=  2.50640D-02

At iterate   20    f=  6.46184D-01    |proj g|=  1.71807D-03

At iterate   25    f=  6.46174D-01    |proj g|=  3.36457D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value
```

```
           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     28     37      1     0     0   9.316D-06   6.462D-01
  F =  0.64617352611971968

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
237.1143047762258
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            5     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.34486D-01    |proj g|=  6.19014D-02

At iterate    5    f=  8.27380D-01    |proj g|=  3.46718D-02
 This problem is unconstrained.
 This problem is unconstrained.
At iterate   10    f=  8.12938D-01    |proj g|=  7.39607D-02

At iterate   15    f=  8.06122D-01    |proj g|=  4.97604D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    5     19     28      1     0     0   3.483D-06   8.061D-01
  F =  0.80609084566844469

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
280.8465241445974
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.61872D-01    |proj g|=  8.42296D-02

At iterate    5    f=  7.47037D-01    |proj g|=  2.51119D-02

At iterate   10    f=  7.38780D-01    |proj g|=  5.41409D-02

At iterate   15    f=  7.33188D-01    |proj g|=  2.20967D-02

At iterate   20    f=  7.32566D-01    |proj g|=  5.39668D-05

           * * *
```

```
Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     22     32      1     0     0   3.343D-06   7.326D-01
  F =  0.73256611014581219

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
258.14221300899294
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.66817D-01    |proj g|=  2.51453D-01
 This problem is unconstrained.
At iterate    5    f=  7.08499D-01    |proj g|=  4.51547D-02

At iterate   10    f=  6.99000D-01    |proj g|=  8.45247D-02

At iterate   15    f=  6.93582D-01    |proj g|=  9.29351D-03

At iterate   20    f=  6.93568D-01    |proj g|=  1.75797D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     20     28      1     0     0   1.758D-05   6.936D-01
  F =  0.69356794346256934

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
247.0388290034233
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.56956D-01    |proj g|=  3.37880D-01
 This problem is unconstrained.
At iterate    5    f=  6.52256D-01    |proj g|=  3.39754D-02
```

```
At iterate   10    f=  6.47007D-01    |proj g|=  1.72677D-02

At iterate   15    f=  6.38699D-01    |proj g|=  2.27746D-02

At iterate   20    f=  6.38482D-01    |proj g|=  2.20088D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     22     29      1     0     0   5.983D-05   6.385D-01
  F =  0.63848204529084374

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
230.52996721772348
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.70565D-01    |proj g|=  8.92913D-02

At iterate    5    f=  7.53941D-01    |proj g|=  2.05962D-02
 This problem is unconstrained.
At iterate   10    f=  7.43267D-01    |proj g|=  3.94023D-02

At iterate   15    f=  7.42874D-01    |proj g|=  1.19270D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     19     23      1     0     0   1.718D-05   7.429D-01
  F =  0.74287381817846243

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
261.6056029079634
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
```

```
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.58978D-01    |proj g|=  8.66470D-02

At iterate    5    f=  7.44396D-01    |proj g|=  2.48974D-02
 This problem is unconstrained.
At iterate   10    f=  7.32046D-01    |proj g|=  1.73258D-01

At iterate   15    f=  7.29726D-01    |proj g|=  1.39074D-01

At iterate   20    f=  7.29214D-01    |proj g|=  2.41961D-01

At iterate   25    f=  7.29147D-01    |proj g|=  1.65171D-02

At iterate   30    f=  7.29139D-01    |proj g|=  2.10166D-02

At iterate   35    f=  7.29137D-01    |proj g|=  4.57621D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     38     51      1     0     0   1.278D-03   7.291D-01
  F =  0.72913733297733363

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
258.9901438803841
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.57996D-01    |proj g|=  2.43142D-01
 This problem is unconstrained.
At iterate    5    f=  7.08522D-01    |proj g|=  1.83267D-02

At iterate   10    f=  6.97676D-01    |proj g|=  7.33356D-02

At iterate   15    f=  6.92053D-01    |proj g|=  5.37947D-03

At iterate   20    f=  6.92008D-01    |proj g|=  2.23454D-03

At iterate   25    f=  6.91990D-01    |proj g|=  1.58279D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
```

```
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     29     36      1     0     0   8.122D-06   6.920D-01
  F =  0.69198979665468374

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
248.50857167597374
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.06004D-01    |proj g|=  4.95051D-01
 This problem is unconstrained.
At iterate    5    f=  6.51817D-01    |proj g|=  2.39582D-02

At iterate   10    f=  6.42976D-01    |proj g|=  3.71135D-02

At iterate   15    f=  6.38862D-01    |proj g|=  3.82521D-02

At iterate   20    f=  6.38546D-01    |proj g|=  6.17011D-03

At iterate   25    f=  6.37473D-01    |proj g|=  4.95594D-03

At iterate   30    f=  6.37427D-01    |proj g|=  3.80267D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     32     53      1     0     0   1.805D-05   6.374D-01
  F =  0.63742651828348706

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
232.17531014325166
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.11319D-01    |proj g|=  1.09094D-01
 This problem is unconstrained.
At iterate    5    f=  6.95052D-01    |proj g|=  1.48011D-02
```

```
At iterate   10    f=  6.87161D-01    |proj g|=  3.18044D-02

At iterate   15    f=  6.83999D-01    |proj g|=  1.52627D-02

At iterate   20    f=  6.83896D-01    |proj g|=  4.15776D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     21     30      1     0     0   3.267D-05   6.839D-01
  F =  0.68389618760981230

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
243.78911903689695
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.10785D-01    |proj g|=  8.17712D-02
 This problem is unconstrained.
At iterate    5    f=  6.97779D-01    |proj g|=  2.54547D-02

At iterate   10    f=  6.81808D-01    |proj g|=  2.62770D-02

At iterate   15    f=  6.79512D-01    |proj g|=  3.77688D-02

At iterate   20    f=  6.77801D-01    |proj g|=  2.72031D-03

At iterate   25    f=  6.77779D-01    |proj g|=  9.28247D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     28     39      1     0     0   1.197D-05   6.778D-01
  F =  0.67777853432755231

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
243.73358753405756
RUNNING THE L-BFGS-B CODE
```

```
           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.33437D-01    |proj g|=  2.22583D-01
 This problem is unconstrained.
At iterate    5    f=  6.91288D-01    |proj g|=  1.58709D-02

At iterate   10    f=  6.82034D-01    |proj g|=  2.11854D-02

At iterate   15    f=  6.81006D-01    |proj g|=  9.13206D-03

At iterate   20    f=  6.77498D-01    |proj g|=  8.87065D-03

At iterate   25    f=  6.77101D-01    |proj g|=  4.70778D-04

At iterate   30    f=  6.77101D-01    |proj g|=  6.37906D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     30     41      1     0     0   6.379D-06   6.771D-01
  F =  0.67710053771907963

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
245.50578067361076
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.62207D-01    |proj g|=  5.56312D-01

At iterate    5    f=  6.58249D-01    |proj g|=  3.39038D-02

At iterate   10    f=  6.45040D-01    |proj g|=  2.92732D-02

At iterate   15    f=  6.40082D-01    |proj g|=  3.54308D-02

At iterate   20    f=  6.38647D-01    |proj g|=  1.87154D-02

At iterate   25    f=  6.37315D-01    |proj g|=  3.23148D-02

At iterate   30    f=  6.34681D-01    |proj g|=  8.40405D-03

At iterate   35    f=  6.34538D-01    |proj g|=  6.31660D-04
```

```
At iterate   40    f=  6.34536D-01    |proj g|=  1.31331D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     40     55      1     0     0   1.313D-05   6.345D-01
  F =  0.63453553164989385

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
233.20393863436433
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.76237D-01    |proj g|=  1.23923D-01
 This problem is unconstrained.
At iterate    5    f=  6.45223D-01    |proj g|=  2.46916D-02

At iterate   10    f=  6.40510D-01    |proj g|=  4.23892D-02

At iterate   15    f=  6.36135D-01    |proj g|=  5.08437D-03

At iterate   20    f=  6.36062D-01    |proj g|=  2.12804D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     24     37      1     0     0   6.799D-06   6.361D-01
  F =  0.63606184264134957

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
229.71677912749345
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10
```

```
At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.75865D-01    |proj g|=  1.23260D-01
 This problem is unconstrained.
At iterate    5    f=  6.45230D-01    |proj g|=  2.72752D-02

At iterate   10    f=  6.39639D-01    |proj g|=  3.93681D-02

At iterate   15    f=  6.33983D-01    |proj g|=  8.15779D-02

At iterate   20    f=  6.31084D-01    |proj g|=  7.02148D-02

At iterate   25    f=  6.30879D-01    |proj g|=  1.01849D-02

At iterate   30    f=  6.30815D-01    |proj g|=  2.55708D-02

At iterate   35    f=  6.30790D-01    |proj g|=  3.94191D-03

At iterate   40    f=  6.30752D-01    |proj g|=  1.65920D-02

At iterate   45    f=  6.30733D-01    |proj g|=  5.79764D-03

At iterate   50    f=  6.30727D-01    |proj g|=  3.89609D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     50     72      1     0     0   3.896D-04   6.307D-01
  F =  0.63072722602333420

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
229.9243479438403
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.97794D-01    |proj g|=  2.13755D-01
 This problem is unconstrained.
At iterate    5    f=  6.44753D-01    |proj g|=  2.14745D-02

At iterate   10    f=  6.39658D-01    |proj g|=  2.93839D-02
  ys=-6.235E-03  -gs= 4.027E-04 BFGS update SKIPPED

At iterate   15    f=  6.34465D-01    |proj g|=  3.16476D-02

At iterate   20    f=  6.32452D-01    |proj g|=  6.25892D-02

At iterate   25    f=  6.31223D-01    |proj g|=  3.06024D-02

At iterate   30    f=  6.30991D-01    |proj g|=  7.36585D-02
```

```
At iterate   35    f=  6.30719D-01    |proj g|=  6.82753D-03

At iterate   40    f=  6.30690D-01    |proj g|=  5.91251D-03

At iterate   45    f=  6.30682D-01    |proj g|=  7.63117D-03

At iterate   50    f=  6.30681D-01    |proj g|=  1.65329D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     50     75      1     1     0   1.653D-03   6.307D-01
  F =  0.63068100664786353

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
231.90881823368215
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           11     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.35760D-01    |proj g|=  4.83405D-01
 This problem is unconstrained.
At iterate    5    f=  6.62680D-01    |proj g|=  5.77626D-02

At iterate   10    f=  6.43816D-01    |proj g|=  5.65565D-02

At iterate   15    f=  6.34432D-01    |proj g|=  1.74535D-01

At iterate   20    f=  6.31255D-01    |proj g|=  2.52666D-01

At iterate   25    f=  6.30953D-01    |proj g|=  4.53654D-03

At iterate   30    f=  6.30789D-01    |proj g|=  1.48480D-02

At iterate   35    f=  6.30676D-01    |proj g|=  6.80681D-02

At iterate   40    f=  6.30642D-01    |proj g|=  7.64932D-03

At iterate   45    f=  6.30580D-01    |proj g|=  3.27705D-03

At iterate   50    f=  6.30574D-01    |proj g|=  1.93028D-02

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
```

```
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   11     50     72      1     0     0   1.930D-02   6.306D-01
  F =  0.63057418559273037

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
233.87292635915742
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            6     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.30042D-01    |proj g|=  2.50323D-01

At iterate    5    f=  8.06862D-01    |proj g|=  2.06987D-01
 This problem is unconstrained.
 This problem is unconstrained.
At iterate   10    f=  8.01311D-01    |proj g|=  6.33265D-03

At iterate   15    f=  8.01234D-01    |proj g|=  6.01545D-03

At iterate   20    f=  8.01109D-01    |proj g|=  1.83237D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    6     23     28      1     0     0   1.527D-05   8.011D-01
  F =  0.80110838083812097

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
281.17241596160864
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.58443D-01    |proj g|=  2.59136D-01

At iterate    5    f=  7.31099D-01    |proj g|=  9.92952D-02

At iterate   10    f=  7.26800D-01    |proj g|=  9.16212D-04

At iterate   15    f=  7.26800D-01    |proj g|=  1.19900D-04
```

```
At iterate   20    f=  7.26800D-01    |proj g|=  2.46166D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     20     25      1     0     0   2.462D-05   7.268D-01
  F =  0.72679954582450279

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
258.20464739703294
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.46482D-01    |proj g|=  2.03222D-01
 This problem is unconstrained.
At iterate    5    f=  6.88756D-01    |proj g|=  3.14457D-02

At iterate   10    f=  6.88199D-01    |proj g|=  3.06602D-03

At iterate   15    f=  6.88181D-01    |proj g|=  3.35145D-03

At iterate   20    f=  6.88176D-01    |proj g|=  1.46209D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     20     24      1     0     0   1.462D-05   6.882D-01
  F =  0.68817576899250721

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
247.22705838148244
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10
```

```
At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.65435D-01    |proj g|=  2.99018D-01
 This problem is unconstrained.
At iterate    5    f=  6.47427D-01    |proj g|=  1.52145D-01

At iterate   10    f=  6.33691D-01    |proj g|=  9.13904D-03

At iterate   15    f=  6.33451D-01    |proj g|=  1.31613D-03

At iterate   20    f=  6.33433D-01    |proj g|=  8.83507D-04

At iterate   25    f=  6.33432D-01    |proj g|=  5.48169D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     25     30      1     0     0   5.482D-05   6.334D-01
  F =  0.63343234258508097

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
230.8332671085872
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.70607D-01    |proj g|=  2.40294D-01
 This problem is unconstrained.
At iterate    5    f=  7.44394D-01    |proj g|=  4.70840D-02

At iterate   10    f=  7.39483D-01    |proj g|=  4.60124D-03

At iterate   15    f=  7.38527D-01    |proj g|=  7.59452D-03

At iterate   20    f=  7.38313D-01    |proj g|=  9.42093D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     22     31      1     0     0   2.084D-05   7.383D-01
```

```
  F =  0.73831269340120032

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
262.0730649828033
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.62041D-01    |proj g|=  2.48112D-01

At iterate    5    f=  7.34480D-01    |proj g|=  9.65442D-02

At iterate   10    f=  7.27501D-01    |proj g|=  8.61475D-03
 This problem is unconstrained.
At iterate   15    f=  7.26566D-01    |proj g|=  3.90128D-02

At iterate   20    f=  7.26460D-01    |proj g|=  2.86677D-03

At iterate   25    f=  7.26457D-01    |proj g|=  2.03427D-03

At iterate   30    f=  7.26440D-01    |proj g|=  3.46102D-03

At iterate   35    f=  7.26431D-01    |proj g|=  1.03356D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     39     55      1     0     0   8.535D-05   7.264D-01
  F =  0.72643057200300798

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
260.0806721930107
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.39457D-01    |proj g|=  1.93540D-01
 This problem is unconstrained.
At iterate    5    f=  6.87274D-01    |proj g|=  2.04616D-02

At iterate   10    f=  6.86951D-01    |proj g|=  5.40451D-03

At iterate   15    f=  6.86603D-01    |proj g|=  9.76074D-04

At iterate   20    f=  6.86602D-01    |proj g|=  1.03731D-04
```

```
At iterate   25    f=  6.86601D-01    |proj g|=  8.05327D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     25     28      1     0     0   8.053D-06   6.866D-01
  F =  0.68660104771001917

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
248.69795203056646
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.20655D-01    |proj g|=  4.77485D-01
 This problem is unconstrained.
At iterate    5    f=  6.43924D-01    |proj g|=  3.75964D-02

At iterate   10    f=  6.34092D-01    |proj g|=  1.00258D-02

At iterate   15    f=  6.33779D-01    |proj g|=  1.01853D-02

At iterate   20    f=  6.32704D-01    |proj g|=  1.53366D-02

At iterate   25    f=  6.32539D-01    |proj g|=  1.98348D-03

At iterate   30    f=  6.32475D-01    |proj g|=  1.29713D-03

At iterate   35    f=  6.32472D-01    |proj g|=  5.83726D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     36     42      1     0     0   1.906D-05   6.325D-01
  F =  0.63247176943453398

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
232.51051453000343
RUNNING THE L-BFGS-B CODE
```

```
           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.08596D-01    |proj g|=  2.12617D-01
 This problem is unconstrained.
At iterate    5    f=  6.85114D-01    |proj g|=  8.43632D-02

At iterate   10    f=  6.80599D-01    |proj g|=  6.61335D-03

At iterate   15    f=  6.80141D-01    |proj g|=  1.35644D-02

At iterate   20    f=  6.79797D-01    |proj g|=  5.05597D-03

At iterate   25    f=  6.79765D-01    |proj g|=  4.98789D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     26     37      1     0     0   1.282D-05   6.798D-01
  F =  0.67976504045126929

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
244.40105359162646
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.09300D-01    |proj g|=  2.10836D-01

At iterate    5    f=  6.89760D-01    |proj g|=  8.35777D-02
 This problem is unconstrained.
At iterate   10    f=  6.79064D-01    |proj g|=  4.40881D-02

At iterate   15    f=  6.75445D-01    |proj g|=  1.32793D-02

At iterate   20    f=  6.75291D-01    |proj g|=  4.12830D-04

At iterate   25    f=  6.75290D-01    |proj g|=  6.03674D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
```

```
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     25     30      1     0     0   6.037D-06   6.753D-01
  F =  0.67529031573941134

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
244.89754608844223
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.24832D-01    |proj g|=  2.00217D-01
 This problem is unconstrained.
At iterate    5    f=  6.78415D-01    |proj g|=  2.37920D-02

At iterate   10    f=  6.75522D-01    |proj g|=  1.31025D-02

At iterate   15    f=  6.75019D-01    |proj g|=  7.73715D-03

At iterate   20    f=  6.74881D-01    |proj g|=  4.95632D-03

At iterate   25    f=  6.74821D-01    |proj g|=  3.79109D-04

At iterate   30    f=  6.74819D-01    |proj g|=  3.47853D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     31     35      1     0     0   3.594D-05   6.748D-01
  F =  0.67481947337860271

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
246.7393430552105
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           11     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.77254D-01    |proj g|=  5.49950D-01
 This problem is unconstrained.
At iterate    5    f=  6.46160D-01    |proj g|=  9.74186D-02
```

```
At iterate   10    f=  6.37158D-01    |proj g|=  1.35689D-02

At iterate   15    f=  6.33653D-01    |proj g|=  1.93962D-02

At iterate   20    f=  6.33065D-01    |proj g|=  4.87704D-03

At iterate   25    f=  6.30034D-01    |proj g|=  2.05143D-02

At iterate   30    f=  6.29332D-01    |proj g|=  1.75780D-03

At iterate   35    f=  6.29252D-01    |proj g|=  4.05318D-03

At iterate   40    f=  6.29232D-01    |proj g|=  2.88827D-04

At iterate   45    f=  6.29232D-01    |proj g|=  6.41240D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   11     45     51      1     0     0   6.412D-06   6.292D-01
  F =  0.62923190889535419

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
233.421921388839
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.69917D-01    |proj g|=  1.62871D-01
 This problem is unconstrained.
At iterate    5    f=  6.33211D-01    |proj g|=  3.31141D-02

At iterate   10    f=  6.32189D-01    |proj g|=  2.71576D-02

At iterate   15    f=  6.32036D-01    |proj g|=  8.50721D-03

At iterate   20    f=  6.31977D-01    |proj g|=  1.61998D-02

At iterate   25    f=  6.31877D-01    |proj g|=  3.08304D-03

At iterate   30    f=  6.31858D-01    |proj g|=  1.80708D-04

At iterate   35    f=  6.31858D-01    |proj g|=  9.16310D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
```

```
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     35     53      1     0     0   9.163D-05   6.319D-01
  F =  0.63185791313520223

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
230.30425881342794
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.70177D-01    |proj g|=  1.62209D-01
 This problem is unconstrained.
At iterate    5    f=  6.33832D-01    |proj g|=  2.77706D-02

At iterate   10    f=  6.30497D-01    |proj g|=  5.63551D-02

At iterate   15    f=  6.29120D-01    |proj g|=  1.02792D-02

At iterate   20    f=  6.28992D-01    |proj g|=  9.83547D-03

At iterate   25    f=  6.28867D-01    |proj g|=  3.43260D-03

At iterate   30    f=  6.28827D-01    |proj g|=  1.39090D-02

At iterate   35    f=  6.28756D-01    |proj g|=  4.53673D-02

At iterate   40    f=  6.28716D-01    |proj g|=  4.14478D-03

At iterate   45    f=  6.28706D-01    |proj g|=  3.48579D-03

At iterate   50    f=  6.28701D-01    |proj g|=  5.81875D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     50     64      1     0     0   5.819D-04   6.287D-01
  F =  0.62870142736563273

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
231.24367959485258
RUNNING THE L-BFGS-B CODE

           * * *
```

```
Machine precision = 2.220D-16
 N =           11     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.86381D-01    |proj g|=  1.66357D-01
 This problem is unconstrained.
At iterate    5    f=  6.31414D-01    |proj g|=  3.02208D-02

At iterate   10    f=  6.29672D-01    |proj g|=  1.64554D-02

At iterate   15    f=  6.29382D-01    |proj g|=  1.21353D-02

At iterate   20    f=  6.29146D-01    |proj g|=  1.35464D-02

At iterate   25    f=  6.28867D-01    |proj g|=  9.96185D-03

At iterate   30    f=  6.28848D-01    |proj g|=  1.85846D-02

At iterate   35    f=  6.28725D-01    |proj g|=  1.10331D-02

At iterate   40    f=  6.28694D-01    |proj g|=  1.75355D-03

At iterate   45    f=  6.28692D-01    |proj g|=  1.21199D-03

At iterate   50    f=  6.28692D-01    |proj g|=  2.44249D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   11     50     58      1     0     0   2.442D-04   6.287D-01
  F =  0.62869209498985812

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
233.24054391659232
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           12     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.59004D-01    |proj g|=  5.03077D-01

At iterate    5    f=  6.63468D-01    |proj g|=  7.89790D-02

At iterate   10    f=  6.40202D-01    |proj g|=  5.52426D-02

At iterate   15    f=  6.35749D-01    |proj g|=  4.54096D-02

At iterate   20    f=  6.34901D-01    |proj g|=  6.02553D-02
```

```
At iterate   25    f=  6.33520D-01    |proj g|=  1.53121D-01

At iterate   30    f=  6.32938D-01    |proj g|=  7.21193D-02

At iterate   35    f=  6.32798D-01    |proj g|=  6.83890D-01

At iterate   40    f=  6.32747D-01    |proj g|=  1.28995D-02

At iterate   45    f=  6.32668D-01    |proj g|=  3.76814D-01

At iterate   50    f=  6.32616D-01    |proj g|=  7.31052D-03

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   12     50     80      1     0     0   7.311D-03   6.326D-01
  F =  0.63261608236925049

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
236.55900367606816
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            7     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.04769D-01    |proj g|=  9.74835D-02

At iterate    5    f=  8.00660D-01    |proj g|=  2.20762D-02
 This problem is unconstrained.
 This problem is unconstrained.
At iterate   10    f=  7.93980D-01    |proj g|=  5.05323D-02

At iterate   15    f=  7.92679D-01    |proj g|=  4.52286D-03

At iterate   20    f=  7.92412D-01    |proj g|=  3.99709D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    7     24     30      1     0     0   1.403D-05   7.924D-01
```

```
  F =  0.79241146689386066

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
280.2502528763372
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.37902D-01    |proj g|=  1.30386D-01

At iterate    5    f=  7.22830D-01    |proj g|=  3.91060D-02

At iterate   10    f=  7.19084D-01    |proj g|=  5.15643D-02

At iterate   15    f=  7.10368D-01    |proj g|=  2.62782D-02

At iterate   20    f=  7.09419D-01    |proj g|=  1.28682D-02

At iterate   25    f=  7.09276D-01    |proj g|=  4.08824D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     26     31      1     0     0   1.792D-05   7.093D-01
  F =  0.70927609701455441

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
254.31676859689028
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.38084D-01    |proj g|=  2.27892D-01
 This problem is unconstrained.
At iterate    5    f=  6.91405D-01    |proj g|=  5.35793D-02

At iterate   10    f=  6.84550D-01    |proj g|=  1.82388D-02

At iterate   15    f=  6.76527D-01    |proj g|=  2.53501D-02

At iterate   20    f=  6.74104D-01    |proj g|=  1.77186D-02

At iterate   25    f=  6.72789D-01    |proj g|=  1.65631D-03

At iterate   30    f=  6.72788D-01    |proj g|=  7.22233D-05
```

```
           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     30     32      1     0     0   7.222D-05   6.728D-01
  F =  0.67278766754389019

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
244.0566562947471
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.65450D-01    |proj g|=  4.77316D-01
 This problem is unconstrained.
At iterate    5    f=  6.38528D-01    |proj g|=  4.52922D-02

At iterate   10    f=  6.27333D-01    |proj g|=  1.86361D-02

At iterate   15    f=  6.21855D-01    |proj g|=  1.30383D-02

At iterate   20    f=  6.21651D-01    |proj g|=  8.06338D-04

At iterate   25    f=  6.21643D-01    |proj g|=  3.67193D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     28     33      1     0     0   1.299D-05   6.216D-01
  F =  0.62164250093878359

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
228.87188031543127
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            8     M =           10
```

```
At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.51840D-01    |proj g|=  1.07904D-01

At iterate    5    f=  7.35801D-01    |proj g|=  3.45323D-02

At iterate   10    f=  7.33579D-01    |proj g|=  3.39569D-02

At iterate   15    f=  7.26031D-01    |proj g|=  9.43749D-03
 This problem is unconstrained.
At iterate   20    f=  7.24871D-01    |proj g|=  3.54977D-03

At iterate   25    f=  7.24863D-01    |proj g|=  3.31063D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    8     25     29      1     0     0   3.311D-06   7.249D-01
  F =  0.72486325385543171

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
259.5540532954251
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.39883D-01    |proj g|=  1.25303D-01

At iterate    5    f=  7.24286D-01    |proj g|=  3.29304D-02

At iterate   10    f=  7.20656D-01    |proj g|=  2.90111D-02
 This problem is unconstrained.
At iterate   15    f=  7.12994D-01    |proj g|=  1.36577D-02

At iterate   20    f=  7.11478D-01    |proj g|=  1.57974D-02

At iterate   25    f=  7.11300D-01    |proj g|=  2.74658D-03

At iterate   30    f=  7.11291D-01    |proj g|=  3.44215D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value
```

```
           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     30     35      1     0     0   3.442D-06   7.113D-01
  F =  0.71129097453117807

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
256.9937674424758
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  7.30111D-01    |proj g|=  2.18478D-01
 This problem is unconstrained.
At iterate    5    f=  6.87330D-01    |proj g|=  2.87247D-02

At iterate   10    f=  6.82438D-01    |proj g|=  2.08135D-02

At iterate   15    f=  6.73875D-01    |proj g|=  1.44280D-02

At iterate   20    f=  6.71856D-01    |proj g|=  2.84840D-02

At iterate   25    f=  6.71602D-01    |proj g|=  2.87756D-03

At iterate   30    f=  6.71418D-01    |proj g|=  1.22922D-03

At iterate   35    f=  6.71413D-01    |proj g|=  1.00852D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     37     42      1     0     0   3.374D-05   6.714D-01
  F =  0.67141329618032430

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
245.59486751658898
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           11     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.24410D-01    |proj g|=  6.82577D-01

At iterate    5    f=  6.35984D-01    |proj g|=  2.53360D-02
```

```
At iterate   10    f=  6.28913D-01    |proj g|=  1.97282D-02

At iterate   15    f=  6.22311D-01    |proj g|=  4.03835D-02

At iterate   20    f=  6.19795D-01    |proj g|=  5.20944D-02

At iterate   25    f=  6.19074D-01    |proj g|=  4.97659D-02

At iterate   30    f=  6.16954D-01    |proj g|=  3.55556D-02

At iterate   35    f=  6.16821D-01    |proj g|=  2.11905D-03

At iterate   40    f=  6.16815D-01    |proj g|=  1.59050D-04

At iterate   45    f=  6.16815D-01    |proj g|=  3.18893D-04

At iterate   50    f=  6.16815D-01    |proj g|=  1.31605D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   11     50     62      1     0     0   1.316D-05   6.168D-01
  F =  0.61681455746827984

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
229.249691309342
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            9     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.96262D-01    |proj g|=  9.95407D-02
 This problem is unconstrained.
At iterate    5    f=  6.78835D-01    |proj g|=  3.80642D-02

At iterate   10    f=  6.74554D-01    |proj g|=  4.04843D-02

At iterate   15    f=  6.66990D-01    |proj g|=  2.15945D-02

At iterate   20    f=  6.64500D-01    |proj g|=  4.37596D-02

At iterate   25    f=  6.62408D-01    |proj g|=  6.49605D-03

At iterate   30    f=  6.62333D-01    |proj g|=  9.85369D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
```

```
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    9     32     45      1     0     0   4.804D-05   6.623D-01
  F =  0.66233250601344040

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
240.543722020516
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.95976D-01    |proj g|=  1.12468D-01
 This problem is unconstrained.
At iterate    5    f=  6.82731D-01    |proj g|=  3.89593D-02

At iterate   10    f=  6.74790D-01    |proj g|=  6.07799D-02

At iterate   15    f=  6.63891D-01    |proj g|=  2.12523D-02

At iterate   20    f=  6.61872D-01    |proj g|=  4.71447D-02

At iterate   25    f=  6.59891D-01    |proj g|=  5.64550D-03

At iterate   30    f=  6.59601D-01    |proj g|=  9.13829D-03

At iterate   35    f=  6.59527D-01    |proj g|=  3.36313D-04

At iterate   40    f=  6.59526D-01    |proj g|=  4.97678D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     42     49      1     0     0   1.810D-05   6.595D-01
  F =  0.65952590079297890

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
241.6007026664409
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           11     M =           10

At X0         0 variables are exactly at the bounds
```

```
At iterate    0    f=  7.11889D-01    |proj g|=  1.87952D-01

At iterate    5    f=  6.74808D-01    |proj g|=  2.54732D-02
 This problem is unconstrained.
At iterate   10    f=  6.65844D-01    |proj g|=  5.66634D-02

At iterate   15    f=  6.55174D-01    |proj g|=  2.93046D-02

At iterate   20    f=  6.51687D-01    |proj g|=  3.61222D-02

At iterate   25    f=  6.50113D-01    |proj g|=  1.46415D-02

At iterate   30    f=  6.49726D-01    |proj g|=  1.22233D-03

At iterate   35    f=  6.49707D-01    |proj g|=  3.73798D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   11     38     43      1     0     0   1.822D-05   6.497D-01
  F =  0.64970712086531157

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
240.30159261074468
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           12     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.65906D-01    |proj g|=  8.44488D-01
 This problem is unconstrained.
At iterate    5    f=  6.39088D-01    |proj g|=  6.51201D-02

At iterate   10    f=  6.27816D-01    |proj g|=  3.66421D-02

At iterate   15    f=  6.21238D-01    |proj g|=  6.03552D-03

At iterate   20    f=  6.14059D-01    |proj g|=  8.73396D-02

At iterate   25    f=  6.07993D-01    |proj g|=  2.29269D-02

At iterate   30    f=  6.05208D-01    |proj g|=  7.14988D-03

At iterate   35    f=  6.04804D-01    |proj g|=  6.55792D-03

At iterate   40    f=  6.04776D-01    |proj g|=  4.58614D-04

           * * *

Tit   = total number of iterations
```

```
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   12     43     60      1     0     0   1.712D-05   6.048D-01
  F =  0.60477543672550116

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
227.2045467397684
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           10     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.63095D-01    |proj g|=  1.38363D-01
 This problem is unconstrained.
At iterate    5    f=  6.35228D-01    |proj g|=  4.88677D-02

At iterate   10    f=  6.30618D-01    |proj g|=  2.16243D-02

At iterate   15    f=  6.18691D-01    |proj g|=  9.43610D-02

At iterate   20    f=  6.15866D-01    |proj g|=  6.63346D-03

At iterate   25    f=  6.15646D-01    |proj g|=  2.36231D-03

At iterate   30    f=  6.15632D-01    |proj g|=  1.55673D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   10     33     42      1     0     0   1.732D-05   6.156D-01
  F =  0.61563170644194332

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
226.85225336449295
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           11     M =           10

At X0         0 variables are exactly at the bounds
```

```
At iterate    0    f=  6.63221D-01    |proj g|=  1.38131D-01
 This problem is unconstrained.
At iterate    5    f=  6.38027D-01    |proj g|=  9.90343D-02

At iterate   10    f=  6.30116D-01    |proj g|=  2.60184D-02

At iterate   15    f=  6.16397D-01    |proj g|=  2.08301D-01

At iterate   20    f=  6.14183D-01    |proj g|=  3.39047D-02

At iterate   25    f=  6.14050D-01    |proj g|=  3.02629D-02

At iterate   30    f=  6.14003D-01    |proj g|=  8.48627D-02

At iterate   35    f=  6.12986D-01    |proj g|=  1.67169D-01

At iterate   40    f=  6.12908D-01    |proj g|=  6.53702D-02

At iterate   45    f=  6.12813D-01    |proj g|=  6.93446D-03

At iterate   50    f=  6.12771D-01    |proj g|=  1.49755D-02

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   11     50     75      1     0     0   1.498D-02   6.128D-01
  F =  0.61277100250757366

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
227.89105684254474
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           12     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  6.81251D-01    |proj g|=  1.90922D-01

At iterate    5    f=  6.35368D-01    |proj g|=  2.56550D-02

At iterate   10    f=  6.30245D-01    |proj g|=  3.72932D-02

At iterate   15    f=  6.27068D-01    |proj g|=  2.99829D-02

At iterate   20    f=  6.17778D-01    |proj g|=  5.17909D-02

At iterate   25    f=  6.15165D-01    |proj g|=  2.47000D-02

At iterate   30    f=  6.11408D-01    |proj g|=  8.66904D-01
```

```
At iterate   35    f=  6.10046D-01    |proj g|=  9.40404D-02

At iterate   40    f=  6.09059D-01    |proj g|=  2.49295D-01

At iterate   45    f=  6.08750D-01    |proj g|=  5.93195D-01

At iterate   50    f=  6.08337D-01    |proj g|=  3.33542D-02

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   12     50     73      1     0     0   3.335D-02   6.083D-01
  F =  0.60833700521985945

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
228.4012337538728
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           13     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.50669D-01    |proj g|=  7.54837D-01
 This problem is unconstrained.
At iterate    5    f=  6.53688D-01    |proj g|=  6.01917D-02

At iterate   10    f=  6.29831D-01    |proj g|=  3.99901D-02

At iterate   15    f=  6.18902D-01    |proj g|=  8.53974D-02

At iterate   20    f=  6.10738D-01    |proj g|=  1.36038D-02

At iterate   25    f=  6.10285D-01    |proj g|=  5.93247D-03

At iterate   30    f=  6.09926D-01    |proj g|=  5.19697D-03

At iterate   35    f=  6.09741D-01    |proj g|=  5.20491D-03

At iterate   40    f=  6.09729D-01    |proj g|=  3.60026D-04

At iterate   45    f=  6.09728D-01    |proj g|=  1.07301D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value
```

```
           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   13     48     54      1     0     0   1.513D-05   6.097D-01
  F =  0.60972824685717153

CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH
230.86869094400964
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           11     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  8.97581D-01    |proj g|=  2.36935D+00
 This problem is unconstrained.
At iterate    5    f=  6.56285D-01    |proj g|=  1.58625D-01

At iterate   10    f=  6.37608D-01    |proj g|=  2.50380D-02

At iterate   15    f=  6.30630D-01    |proj g|=  1.76606D-02

At iterate   20    f=  6.24395D-01    |proj g|=  5.75407D-02

At iterate   25    f=  6.20581D-01    |proj g|=  2.22518D-02

At iterate   30    f=  6.12826D-01    |proj g|=  6.55121D-02

At iterate   35    f=  6.07742D-01    |proj g|=  2.52122D-02

At iterate   40    f=  6.05760D-01    |proj g|=  2.06324D-02

At iterate   45    f=  6.04960D-01    |proj g|=  1.36755D-03

At iterate   50    f=  6.04954D-01    |proj g|=  1.95574D-04

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   11     50     62      1     0     0   1.956D-04   6.050D-01
  F =  0.60495385060557627

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
Best SARIMA Model: SARIMA(2, 1, 3, 2, 1, 3) (seasonal period = 12)
                                SARIMAX Results

==========================================================================================
==
Dep. Variable:                                Sales   No. Observations:                  1
68
Model:             SARIMAX(2, 1, 3)x(2, 1, 3, 12)   Log Likelihood                -101.6
32
```

```
Date:                           Mon, 30 Oct 2023   AIC                            225.2
64
Time:                                  18:48:49   BIC                            255.4
59
Sample:                                     0   HQIC                           237.5
20
                                          - 168

Covariance Type:                          opg

==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ar.L1         -0.5518      0.080     -6.871      0.000      -0.709      -0.394
ar.L2         -0.7734      0.084     -9.179      0.000      -0.939      -0.608
ma.L1         -0.3141      9.833     -0.032      0.975     -19.587      18.959
ma.L2          0.6866     39.072      0.018      0.986     -75.892      77.265
ma.L3         -0.7385     34.220     -0.022      0.983     -67.808      66.331
ar.S.L12      -0.5556      0.195     -2.851      0.004      -0.938      -0.174
ar.S.L24      -0.4890      0.172     -2.843      0.004      -0.826      -0.152
ma.S.L12       0.1805      0.223      0.810      0.418      -0.256       0.617
ma.S.L24       0.3033      0.202      1.498      0.134      -0.094       0.700
ma.S.L36      -0.0547      0.125     -0.437      0.662      -0.300       0.191
sigma2         0.3267     15.141      0.022      0.983     -29.349      30.002
===================================================================================
Ljung-Box (L1) (Q):                   0.00   Jarque-Bera (JB):                 8.74
Prob(Q):                              0.95   Prob(JB):                         0.01
Heteroskedasticity (H):               5.13   Skew:                            -0.46
Prob(H) (two-sided):                  0.00   Kurtosis:                         3.99
===================================================================================

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
```

8A)

In [15]:

```
# PART 8A:
testset = pharma_data[168 : ]
p = 2
d = 1
q = 3
P = 2
D = 1
Q = 3

best_model = sm.tsa.SARIMAX(trainset['Sales'], order=(p, d, q), seasonal_order=(P, D, Q,
best_model_fit = best_model.fit()
predictions=best_model_fit.forecast(36)
```

```
 This problem is unconstrained.
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =           11     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  1.14948D+00    |proj g|=  2.95380D+00

At iterate    5    f=  8.58155D-01    |proj g|=  1.37487D-01
```

```
At iterate   10    f=  7.83707D-01    |proj g|=  3.11468D-02

At iterate   15    f=  7.82873D-01    |proj g|=  1.56837D-02

At iterate   20    f=  7.82753D-01    |proj g|=  4.53157D-03

At iterate   25    f=  7.82722D-01    |proj g|=  3.08611D-03

At iterate   30    f=  7.82210D-01    |proj g|=  2.16453D-02

At iterate   35    f=  7.78648D-01    |proj g|=  6.21804D-02

At iterate   40    f=  7.72752D-01    |proj g|=  2.38767D-02

At iterate   45    f=  7.70817D-01    |proj g|=  1.69276D-02

At iterate   50    f=  7.64224D-01    |proj g|=  6.27346D-02

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
   11     50     63      1     0     0   6.273D-02   7.642D-01
  F =  0.76422448717798208

STOP: TOTAL NO. of ITERATIONS REACHED LIMIT
```

In [16]:
```
testset["prediction"] = predictions
testset
```

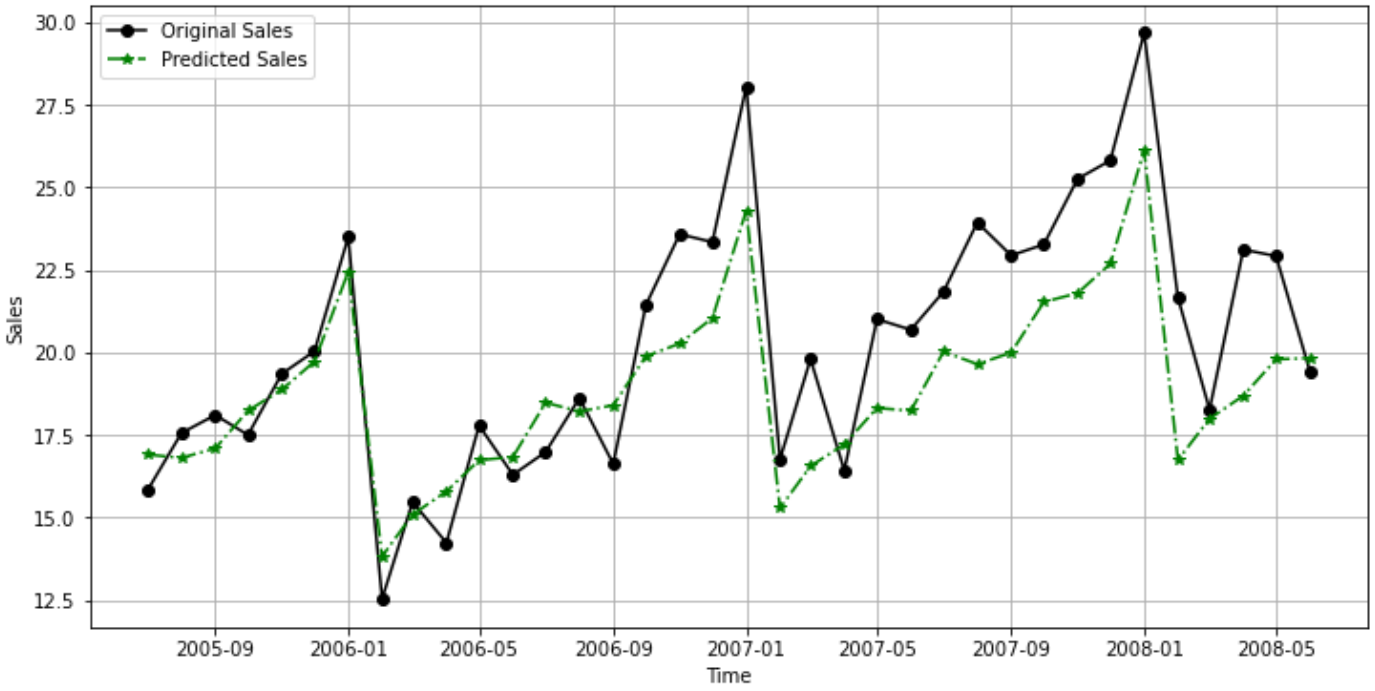
Out[16]:

	Month	Sales	Moving Average	prediction
168	2005-07-01	15.829550	15.985782	16.902176
169	2005-08-01	17.554701	16.167777	16.802333
170	2005-09-01	18.100864	16.331015	17.091382
171	2005-10-01	17.496668	16.398591	18.229050
172	2005-11-01	19.347265	16.541136	18.868575
173	2005-12-01	20.031291	16.637966	19.720662
174	2006-01-01	23.486694	16.863631	22.437812
175	2006-02-01	12.536987	16.895500	13.817875
176	2006-03-01	15.467018	17.067552	15.088746
177	2006-04-01	14.233539	17.048744	15.787315
178	2006-05-01	17.783058	17.297740	16.733295
179	2006-06-01	16.291602	17.346603	16.830020
180	2006-07-01	16.980282	17.442497	18.475998
181	2006-08-01	18.612189	17.530621	18.206811
182	2006-09-01	16.623343	17.407495	18.395711

183	2006-10-01	21.430241	17.735292	19.877506
184	2006-11-01	23.575517	18.087647	20.265329
185	2006-12-01	23.334206	18.362890	21.033709
186	2007-01-01	28.038383	18.742197	24.284290
187	2007-02-01	16.763869	19.094437	15.281701
188	2007-03-01	19.792754	19.454915	16.554246
189	2007-04-01	16.427305	19.637729	17.211212
190	2007-05-01	21.000742	19.905869	18.314535
191	2007-06-01	20.681002	20.271653	18.228071
192	2007-07-01	21.834890	20.676203	20.019287
193	2007-08-01	23.930204	21.119371	19.639391
194	2007-09-01	22.930357	21.644956	19.989743
195	2007-10-01	23.263340	21.797714	21.521625
196	2007-11-01	25.250030	21.937257	21.789612
197	2007-12-01	25.806090	22.143247	22.679834
198	2008-01-01	29.665356	22.278828	26.108347
199	2008-02-01	21.654285	22.686363	16.737836
200	2008-03-01	18.264945	22.559045	17.990453
201	2008-04-01	23.107677	23.115743	18.684940
202	2008-05-01	22.912510	23.275057	19.786641
203	2008-06-01	19.431740	23.170952	19.823521

8B)

In [17]:
```
# PART 8B:
# Plot of predicted values overlaid on the original data
plt.figure(figsize=(12,6))
plt.plot(testset['Month'], testset['Sales'], label='Original Sales', c='black', linestyl
plt.plot(testset['Month'], testset['prediction'], label='Predicted Sales', c='green', li
plt.xlabel('Time')
plt.ylabel('Sales')
plt.legend()
plt.grid(True)
plt.show()
```



8C)

In [18]:
```
# PART 8C:
# Calculating the MSE between the original data and the predicted values
from sklearn.metrics import mean_squared_error

# Compute the MSE
mse = mean_squared_error(pharma_data['Sales'].iloc[168:], testset['prediction'])

print(f"Mean Squared Error (MSE): {mse}")
```

```
Mean Squared Error (MSE): 5.462130003412936
```

From the table and the plot we can see that the predicted values are very close to the actual/original data points for the Sales column. The MSE value of 5.462130003412936 indicates that our model captures the underlying patterns and trends in the data fairly well. It is noteworthy that the discrepancies between the predicted values and actual values is quite common and our model does a decent job, further analysis might even reduce this MSE and we might be able to get better predictions.

Problem 2

A)

In [19]:
```
wine_data = pd.read_csv('TotalWine.csv')
wine_data
```

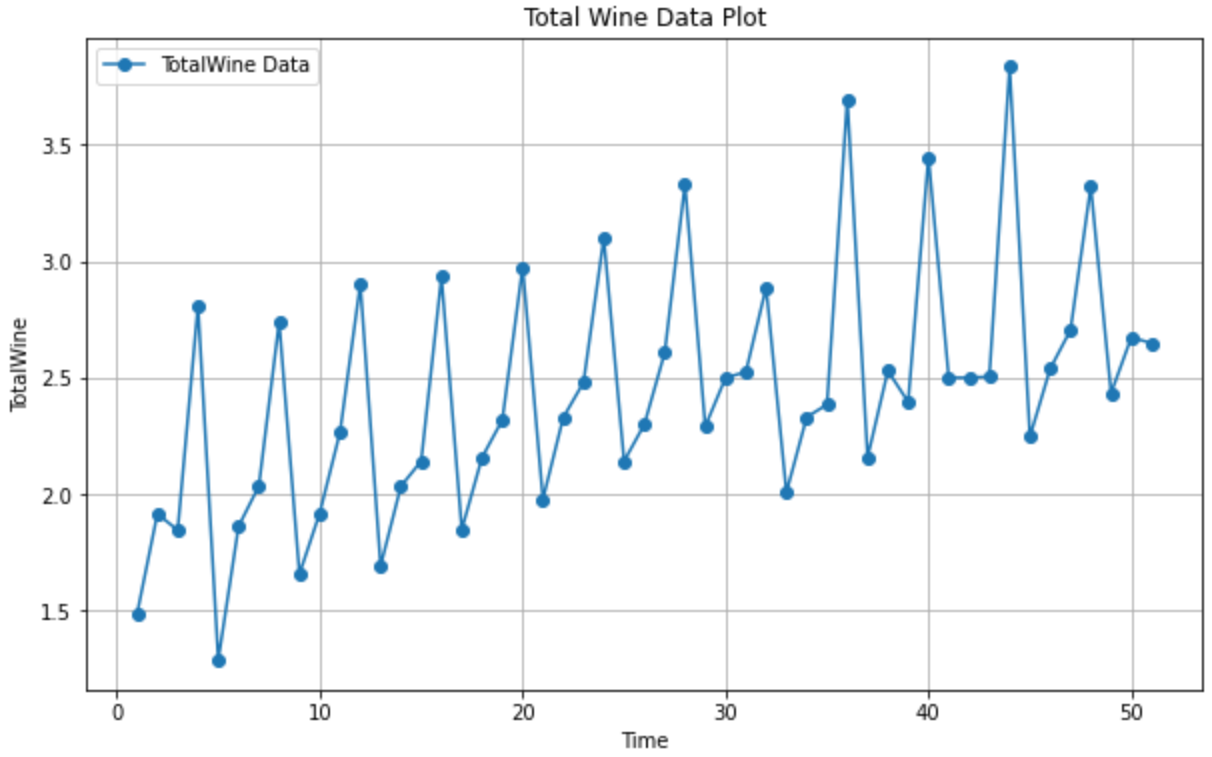
Out[19]:

	Time (Quarter)	TotalWine
0	1	1.486
1	2	1.915
2	3	1.844
3	4	2.808

4	5	1.287
5	6	1.861
6	7	2.034
7	8	2.739
8	9	1.656
9	10	1.918
10	11	2.265
11	12	2.902
12	13	1.691
13	14	2.033
14	15	2.141
15	16	2.932
16	17	1.847
17	18	2.157
18	19	2.318
19	20	2.974
20	21	1.977
21	22	2.328
22	23	2.479
23	24	3.099
24	25	2.141
25	26	2.299
26	27	2.606
27	28	3.330
28	29	2.290
29	30	2.499
30	31	2.524
31	32	2.887
32	33	2.007
33	34	2.330
34	35	2.384
35	36	3.696
36	37	2.157
37	38	2.529
38	39	2.395
39	40	3.447
40	41	2.499
41	42	2.499
42	43	2.504

43	44	3.834
44	45	2.246
45	46	2.538
46	47	2.704
47	48	3.321
48	49	2.433
49	50	2.673
50	51	2.647

In [20]:
```
plt.figure(figsize=(10,6))
plt.plot(wine_data['Time (Quarter)'], wine_data['TotalWine'], label="TotalWine Data", ma
plt.xlabel('Time')
plt.ylabel('TotalWine')
plt.title('Total Wine Data Plot')
plt.legend()
plt.grid(True)
plt.show()
```

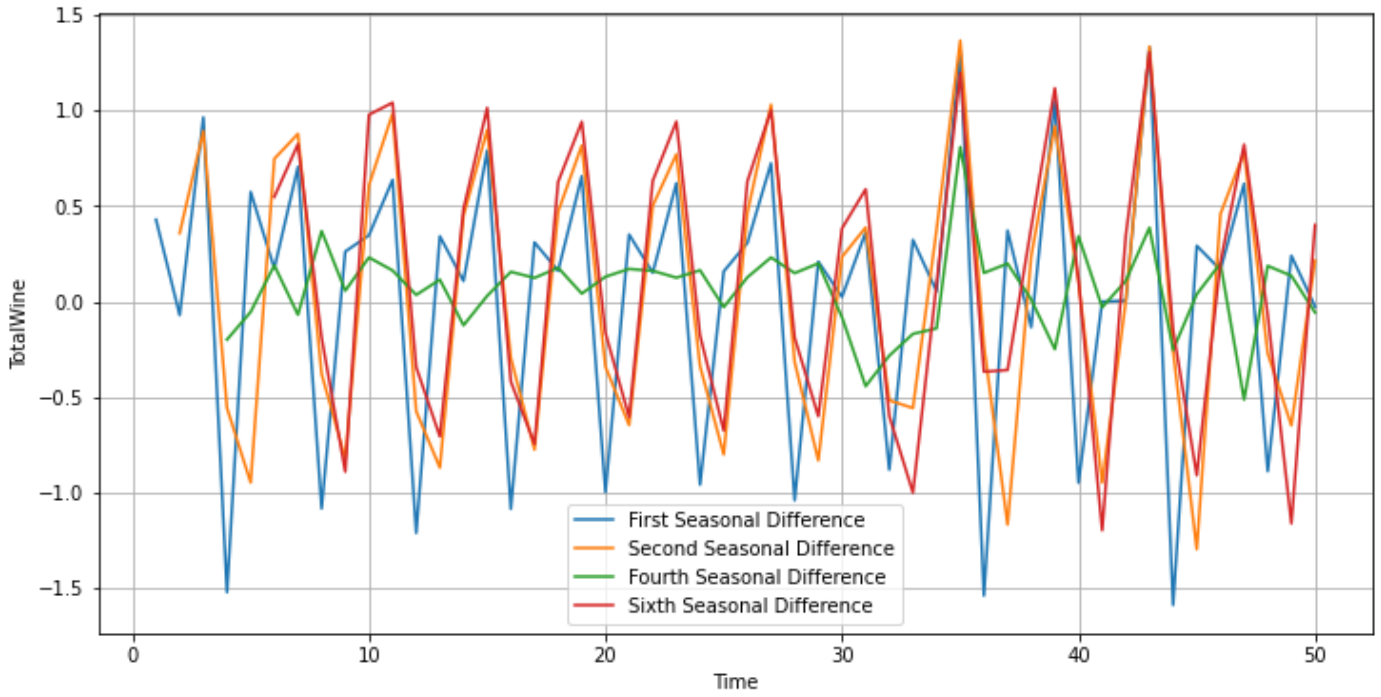


The seasonal period of this time series seems to be every 4 quarters so one possible interpretation of this would be annual seasonality as there are 4 quarters in a fiscal year.

B)

In [21]:
```
# Seasonal Differencing
seasonal_diff1 = wine_data['TotalWine'].diff(1)
seasonal_diff2 = wine_data['TotalWine'].diff(2)
seasonal_diff4 = wine_data['TotalWine'].diff(4)
seasonal_diff6 = wine_data['TotalWine'].diff(6)
# pos 0 for diff1 nan, pos 0 and 1 for diff2 nan, pos 0,1,2,3 for diff4 nan, pos 0,1,2,3

# Plots
```

```
plt.figure(figsize=(12,6))
plt.plot(seasonal_diff1, label='First Seasonal Difference')
plt.plot(seasonal_diff2, label='Second Seasonal Difference')
plt.plot(seasonal_diff4, label='Fourth Seasonal Difference')
plt.plot(seasonal_diff6, label='Sixth Seasonal Difference')
plt.xlabel('Time')
plt.ylabel('TotalWine')
plt.legend()
plt.grid(True)
plt.show()
```

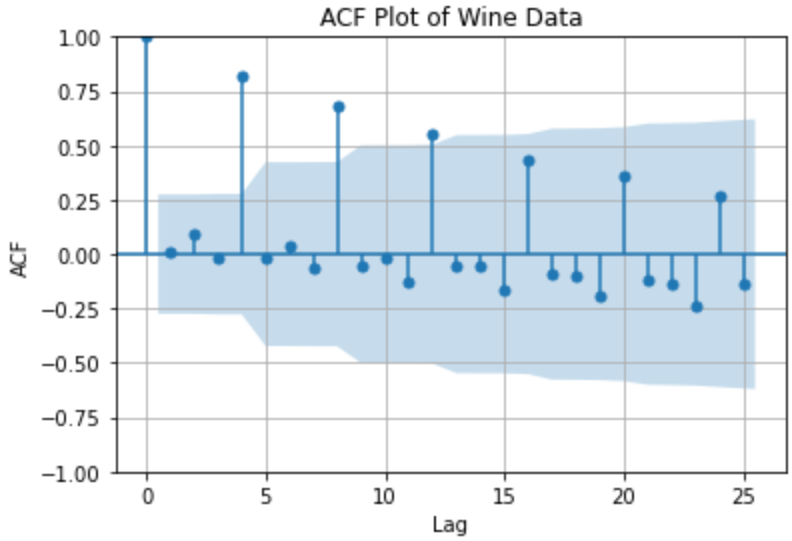


From the above plot the fourth seasonal difference i.e. lag 4 seems to be the most suitable to remove the seasonality.

C)

In [22]:

```
# Plotting ACF of the Original Time Series
plot_acf(wine_data['TotalWine'], lags=25)
plt.title('ACF Plot of Wine Data')
plt.xlabel('Lag')
plt.ylabel('ACF')
plt.grid(True)
plt.show()
```



From the above ACF plot of the wine data, the significant peaks seem to be at lag 4, lag 8, lag 12 and so on. Therefore, the seasonal period is every 4 quarters or in other words annual but in terms of quarters not months.

In [23]:
```
from statsmodels.tsa.ar_model import AutoReg

best_order = None
min_aic = float('inf')

# Iterate through different lag orders and calculate AIC
# NOTE: I am running the following search for best AR order on the fourth seasonal data
####### If it is run on the original time series the best AR order found by minimum AIC
####### value method comes out to be 8, however, here we find it to be 4.
for p in range(1, 11):
    model = sm.tsa.AutoReg(seasonal_diff4.dropna(), lags=p)
    results = model.fit()
    aic = results.aic
    print(f"AIC for order {p}: {aic}")
    if aic < min_aic:
        min_aic = aic
        best_order = p

# Printing the optimal AR order and its corresponding AIC
print("Minimum AIC:", min_aic)
print("Optimal AR Order (p) based on Minimum AIC:", best_order)
```

```
AIC for order 1: -3.2585296001103874
AIC for order 2: -0.43612691994517405
AIC for order 3: 2.2955947939000376
AIC for order 4: -18.571190665860307
AIC for order 5: -16.137237852006194
AIC for order 6: -13.649083439021595
AIC for order 7: -14.197955461006565
AIC for order 8: -11.229617621206952
AIC for order 9: -8.072504350825529
AIC for order 10: -5.124304330227638
Minimum AIC: -18.571190665860307
Optimal AR Order (p) based on Minimum AIC: 4
```

E

i)

In [24]:
```
ar_model = ARIMA(seasonal_diff4.dropna(),order=(4,0,0))
model_fit = ar_model.fit()
model_fit.summary()
```

Out[24]:

SARIMAX Results

Dep. Variable:	TotalWine	**No. Observations:**	47
Model:	ARIMA(4, 0, 0)	**Log Likelihood**	16.370
Date:	Mon, 30 Oct 2023	**AIC**	-20.739
Time:	18:48:53	**BIC**	-9.638
Sample:	0	**HQIC**	-16.562
	- 47		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
const	0.0725	0.018	4.034	0.000	0.037	0.108
ar.L1	-0.0072	0.112	-0.064	0.949	-0.227	0.213
ar.L2	0.0470	0.167	0.282	0.778	-0.280	0.374
ar.L3	0.0600	0.097	0.618	0.537	-0.130	0.250
ar.L4	-0.6652	0.120	-5.546	0.000	-0.900	-0.430
sigma2	0.0277	0.007	4.119	0.000	0.015	0.041

Ljung-Box (L1) (Q):	0.44	**Jarque-Bera (JB):**	0.43
Prob(Q):	0.51	**Prob(JB):**	0.80
Heteroskedasticity (H):	3.07	**Skew:**	-0.18
Prob(H) (two-sided):	0.03	**Kurtosis:**	3.29

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

ii)

In [25]:
```
preds = model_fit.predict()

# Taking a look at the prediction values starting from the optimal lag
preds
```

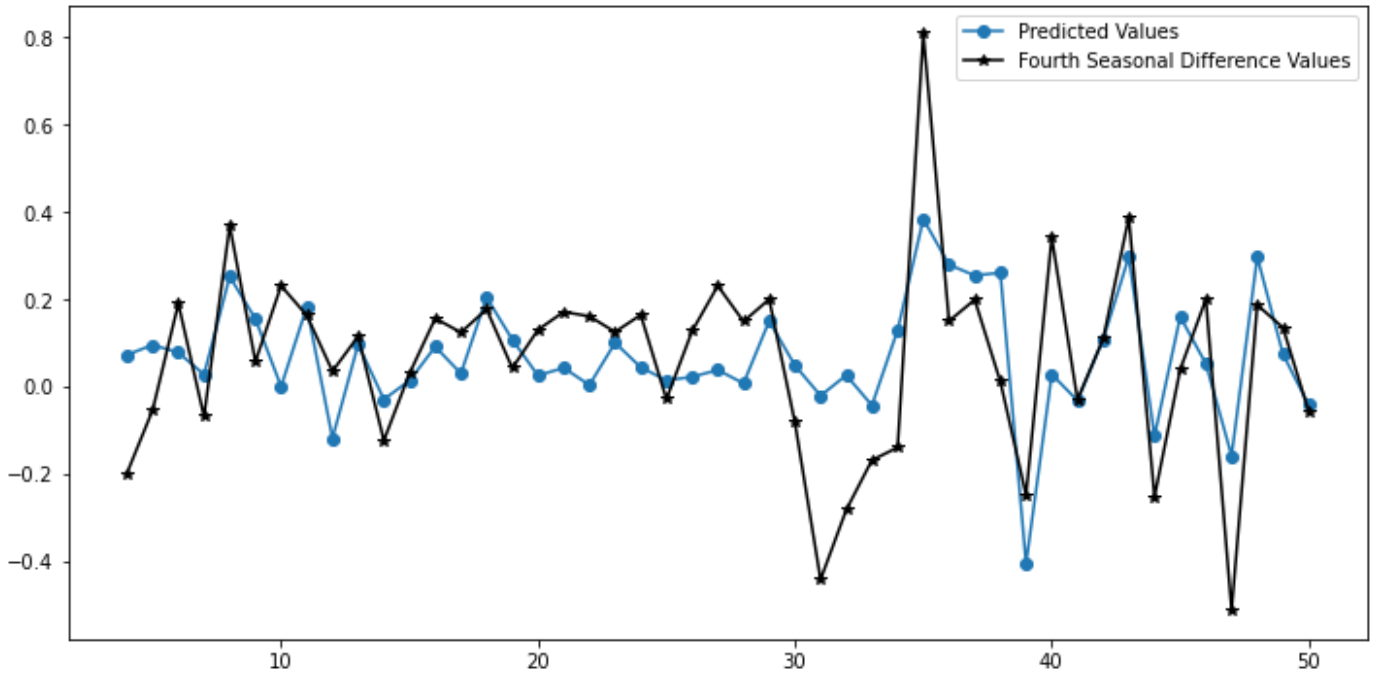
Out[25]:
```
4     0.072507
5     0.095271
6     0.077843
7     0.027467
8     0.252057
9     0.154932
10   -0.000086
11    0.182566
12   -0.118841
13    0.096858
14   -0.029558
15    0.013466
```

```
16    0.091069
17    0.029851
18    0.204228
19    0.107467
20    0.025191
21    0.042679
22    0.003167
23    0.100249
24    0.043960
25    0.014115
26    0.021822
27    0.037916
28    0.006983
29    0.150205
30    0.048456
31   -0.021228
32    0.025701
33   -0.043271
34    0.129355
35    0.384244
36    0.279226
37    0.254483
38    0.260804
39   -0.406360
40    0.027960
41   -0.032376
42    0.107534
43    0.297461
44   -0.113444
45    0.160005
46    0.052038
47   -0.158714
48    0.297208
49    0.074091
50   -0.042502
Name: predicted_mean, dtype: float64
```

iii)

In [26]:

```
plt.figure(figsize=(12,6))
plt.plot(preds,label = 'Predicted Values', marker='o')
plt.plot(seasonal_diff4,label = 'Fourth Seasonal Difference Values', c='black', marker='
plt.legend()
plt.show()
```



iv)

In [27]:
```
# Calculating the Mean Absolute Error (MAE) by comparing predicted results with the seas
mae = np.mean(np.abs(preds - seasonal_diff4))
print('The Mean Absolute Error (MAE) is', mae)
```

```
The Mean Absolute Error (MAE) is 0.13461884335362367
```

In [ ]: