PART A (Attempt any **two** questions in PART A)

1. Correct the conceptual and syntax errors in the codes for sTLBO and Production Planning. Incorporate the correction approach wherein a solution is corrected (instead of being penalized) for violating the domain hole constraints. [5]

2. Use *intlinprog* to solve the MILP formulation of production planning problem. [5]

3. Solve the following problem by branch & bound method. Use *linprog* to solve the linear programming problems.

   Do **not** use *intlinprog*. [5]

$$\begin{aligned}&\textit{Minimize} \quad f(x) = 7x_1 + 7x_2 + 25x_3\\ &s.t \quad 4x_1 + 26x_2 + 2x_3 \le 182; \quad -6x_1 - 16x_2 - 22x_3 \ge -338;\\ &5x_1 + 11x_2 + 18x_3 = 262.23; \quad 2 \le x_{1,} x_{2,} x_3 \le 15; \quad x_1 \textit{ and } x_3 \textit{ are integers}\end{aligned}$$

4. Write a generic code to solve the Job Shop Scheduling problem using sTLBO (code given in Q1). [5 + **5 Bonus marks**]

PART B

1. For the population (along with random numbers, other required parameters) given in the text file, perform SBX crossover and polynomial mutation. [3]

2. Use the data given in the excel sheet to plot appropriate convergence curves to be able to analyze all the runs of the three algorithms. If you write a correct code, you will be able to get three additional bonus marks. [3]

PART C

1. For the data given in the excel sheet for NSF panel assignment problem, determine the values of the variable $x(i, j, jj)$ with $i = 5$. Assume dataset has feasible solution. Repeat for $i = 14$. You may choose to code. [4]

2. Use the data given in the excel file. In the context of *intlinprog,* form A, Aeq, b, beq for the NSF panel assignment problem. You may choose to make use of the given excel file. [5]

PART D

1. Solve the Production Planning Problem using sTLBO, PSO, DE and plot the convergence curves (as required in Part B, Q2) and determine the performance statistics of the algorithms (with and without correction approach). Perform 25 runs with the termination criterion of 10,100 objective function evaluations. **[10]**

2. Solve the Production Planning Problem using sTLBO employing the multi-unit approach discussed in class (but not in slides) **Hint:** N_l, N_m, N_h number of units at l,m,h levels respectively along with one variable each to determine production in the *l-m* range and *m-h* range (i.e., 5 variables per process) **[10]**

3. Write a generic code to solve the NSF panel assignment problem using *intlingprog.* If you attempt this, you are not eligible for C2 **[10]**

$$\text{Min} \sum_{i\in I}\sum_{j\in J_i} w_{i,j} y(i,j)$$

$$\left\lfloor \frac{NK}{M} \right\rfloor \le \sum_{i\in I_j} y(i,j) \le \left\lceil \frac{NK}{M} \right\rceil, \forall j \in J \qquad (2)$$

$$\left\lfloor \frac{N}{M} \right\rfloor \le \sum_{i\in I_j} L(i,j) \le \left\lceil \frac{N}{M} \right\rceil, \quad \forall j \in J \qquad (3)$$

$$\left\lfloor \frac{N}{M} \right\rfloor \le \sum_{i\in I_j} S(i,j) \le \left\lceil \frac{N}{M} \right\rceil, \quad \forall j \in J \qquad (4)$$

$$\left\lfloor \frac{N}{M} \right\rfloor \le \sum_{i\in I_j} R1(i,j) \le \left\lceil \frac{N}{M} \right\rceil, \quad \forall j \in J \qquad (5)$$

$$\left\lfloor \frac{N}{M} \right\rfloor \le \sum_{i\in I_j} R2(i,j) \le \left\lceil \frac{N}{M} \right\rceil, \quad \forall j \in J, K=4 \qquad (6)$$

$$\sum_{j\in J_i} y(i,j) = K, \quad \forall i \in I \qquad (7)$$

$$\sum_{j\in J_i} L(i,j) = 1, \quad \forall i \in I \qquad (8)$$

$$\sum_{j\in J_i} S(i,j) = 1, \quad \forall i \in I \qquad (9)$$

$$\sum_{j\in J_i} R1(i,j) = 1, \quad \forall i \in I \qquad (10)$$

$$\sum_{j\in J_i} R2(i,j) = 1, \quad \forall i \in I, K=4 \qquad (11)$$

$$L(i,j) + S(i,j) + R1(i,j) + R2(i,j) = y(i,j), \quad \forall i \in I, j \in J_i \qquad (12)$$

$$L(i,j) \le y(i,j), \quad \forall i \in I, j \in J_i \qquad (13)$$

$$S(i,j) \le y(i,j), \quad \forall i \in I, j \in J_i \qquad (14)$$

$$R1(i,j) \le y(i,j), \quad \forall i \in I, j \in J_i \qquad (15)$$

$$R2(i,j) \le y(i,j), \quad \forall i \in I, j \in J_i, K=4 \qquad (16)$$

$$L(i,j) + S(i,jj) - x(i,j,jj) \le 1, \quad \forall i \in I; j, jj \in J_i; j \ne jj \qquad (17)$$

$$S(i,j) + R1(i,jj) - x(i,j,jj) \le 1, \quad \forall i \in I; j, jj \in J_i; j \ne jj \qquad (18)$$

$$R1(i,j) + R2(i,jj) - x(i,j,jj) \le 1, \quad \forall i \in I; j, jj \in J_i; j \ne jj; K=4 \qquad (19)$$

$$-N(1 - x(i,j,jj)) \le w_{i,jj} - w_{i,j} \quad \forall i \in I; j, jj \in J_i; j \ne jj \qquad (20)$$

$$w_{i,jj} - w_{i,j} + sl(i,j,jj) \le Nx(i,j,jj) \quad \forall i \in I; j, jj \in J_i; j \ne jj \qquad (21)$$

$$\text{Max profit } = \sum_{j=1}^{J} \left(SP_j \cdot X_j - PC_j \right)$$

$$PC_j = cl_j \cdot L_j + cm_j \cdot M_j + ch_j \cdot H_j \quad \forall j = 1,2,\dots,J$$

$$\sum_{j=1}^{J} IC_j \le B$$

$$IC_j = il_j \cdot L_j + im_j \cdot M_j + ih_j \cdot H_j \quad \forall j = 1,2,\dots,J$$

$$\sum_{j=1}^{J} rm_{jk} \cdot X_j \le R_k \qquad k = 1,\dots,K$$

$$\begin{array}{ll}
L_j \le Y_j & \forall j = 1,2,\dots,J \\
H_j \le 1 - Y_j & \forall j = 1,2,\dots,J \\
L_j + M_j + H_j = Z_j & \forall j = 1,2,\dots,J \\
X_j = l_j \cdot L_j + m_j \cdot M_j + h_j \cdot H_j & \forall j = 1,2,\dots,J \\
X_j \le U \cdot Z_j & \forall j = 1,2,\dots,J \\
Y_j, Z_j = 0 \text{ or } 1 & \forall j = 1,2,\dots,J \\
X_j, L_j, M_j, H_j \ge 0 & \forall j = 1,2,\dots,J
\end{array}$$

$$\beta = \begin{cases} (2u)^{1/(\eta_c+1)} & \text{if } u \le 0.5 \\ \left(\dfrac{1}{2(1-u)} \right)^{1/(\eta_c+1)} & \text{otherwise} \end{cases}$$

$$O_1 = 0.5\left[(1+\beta) P_a' + (1-\beta) P_b' \right]$$

$$O_2 = 0.5\left[(1-\beta) P_a' + (1+\beta) P_b' \right]$$

$$\delta = \begin{cases} (2r)^{1/(\eta_m+1)} - 1 & \text{if } r < 0.5 \\ 1 - \left[2(1-r) \right]^{1/(\eta_m+1)} & \text{if } r \ge 0.5 \end{cases}$$

$$O_1 = O_1 + \left(x^u - x^l \right) \times \delta$$