1. (20 points) Give a full description of the scheduling problems denoted by the following \( \alpha | \beta | \gamma \) notation shown below.

(a) R3 \( | r_j, \text{intree} | \sum U_j \)

(b) Q \( | \text{prmp, } \bar{d}_j | \sum C_j \)

(c) Pm \( | P_j = 1, \text{chains} | C_{\text{max}} \)

(d) 1 \( | \text{prec} | \sum W_j C_j \)

2. (20 points) Give the computational complexity of the following scheduling problems — NP-hard or polynomially solvable or OPEN?

(a) P3 \( || C_{\text{max}} \)

(b) P2 \( | P_j = 1, \text{chains} | C_{\text{max}} \)

(c) 1 \( | \text{prec} | C_{\text{max}} \)

(d) P4 \( | P_j = 1, \text{prec} | C_{\text{max}} \)

(e) P7 \( | P_j = 1, \text{intree} | C_{\text{max}} \)

3. (20 points) Show that

(a) P3 \( || C_{\text{max}} \) is NP-hard by showing the decision version of P3 \( || C_{\text{max}} \) is NP-complete. (Hint: Use PARTITION as the source problem in the reduction.)

(b) Pm \( || C_{\text{max}} \) is NP-hard for fixed \( m > 3 \) by showing the decision version of Pm \( || C_{\text{max}} \) is NP-complete. (Hint: Also use PARTITION as the source problem in the reduction. Generalize the reduction given in part (a).)
4. (20 points) Use Hu’s algorithm to construct a schedule for the following jobs on 4 identical and parallel machines. Each job has a processing time of 1 unit.

5. (20 points) Use Coffman-Graham algorithm to construct a schedule for the following jobs on 2 identical and parallel machines. Each job has a processing time of 1 unit.