**2018年-2019学年度第一学期**

**华中科技大学本科生课程考试试卷(B卷)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **课程名称： 运筹学（一）** | **课程类别** | **□公共课**  **■专业课** | **考试形式** | **□开卷**  **■闭卷** |
| **所在院系： 自动化学院 专业及班级： 考试日期： 2019.1.6** | | | | |
| **学 号： 姓名： 任课教师：** | | | | |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **题号** | **一** | **二** | **三** | **四** | **五** | **六** | **总分** |
| **分数** |  |  |  |  |  |  |  |

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| --- | --- |
| **得分** | **评卷人** |
|  |  |

1. **（20分）**试用大M法求解以下线性规划问题，并指出解属于哪一类解，为什么？



解：将上述问题化为标准型：



初始单纯形表为：

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | 2 | 3 | 1 | 0 | M | 0 | M |  |
|  |  |  |  |  |  |  |  |  |  |  |
| M |  | 8 | 1 | [4] | 2 | -1 | 1 | 0 | 0 | 8/4 |
| M |  | 6 | 3 | 2 | 0 | 0 | 0 | -1 | 1 | 6/2 |
|  | |  | 2-4M | 3-6M | 1-2M | M |  | M |  |  |

选取为换入变量，为换出变量，进行第一次迭代。

第一次迭代后的表格：

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | 2 | 3 | 1 | 0 | M | 0 | M |  |
|  |  |  |  |  |  |  |  |  |  |  |
| 3 |  | 2 | 1/4 | 1 | 1/2 | -1/4 | 1/4 | 0 | 0 | 8 |
| M |  | 2 | [5/2] | 0 | -1 | 1/2 | -1/2 | -1 | 1 | 4/5 |
|  | |  | 5/4-5/2M | 0 | -1/2+M | 3/4-M/2 | 3/2M-3/4 | M | 0 |  |

选取为换入变量，为换出变量，进行第二次迭代。

第二次迭代后的表格：

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | 2 | 3 | 1 | 0 | M | 0 | M |  |
|  |  |  |  |  |  |  |  |  |  |  |
| 3 |  | 9/5 | 0 | 1 | 3/5 | -3/10 | 3/10 | 1/10 | -1/10 |  |
| 2 |  | 4/5 | 1 | 0 | -2/5 | 1/5 | -1/5 | -2/5 | 2/5 |  |
|  | |  | 0 | 0 | 0 | 1/2 | M-1/2 | 1/2 | M-1/2 |  |

所有非基变量的检验数都是 ，该解为最优解，最优解为： ，最优值为： 。

由于非基变量 的检验数为0，所以该解为无穷多最优解。

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**二、（10分）表1是某一求极大化问题的单纯形表，表中无人工变量，为待定常数，试说明分别取何值时，以下结论成立：**

1. **表中解为唯一最优解；**
2. **表中解为无穷多最优解之一；**
3. **下一步迭代将以替换基变量;**
4. **该线性规划问题具有无界解；**

**表1**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | |  |  |  |  |  |
|  |  | **4** |  | **1** | **0** | **0** |
|  | **2** | **-1** | **-5** | **0** | **1** | **0** |
|  | **3** |  | **-3** | **0** | **0** | **1** |
|  | |  |  | **0** | **0** | **0** |

答：

1. ；
2. 表中解为无穷多最优解之一: ；
3. 下一步迭代将以替换基变量:
4. 该线性规划问题具有无界解:；

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|  |  |

**三（20分）、已知线性规划问题：**

**假设在上述线性规划问题的第个约束条件中加入松弛变量** **(这里)**，**用单纯形法求解，初表和终表如表2和表3所示。**

**（1）填完初表和终表的空白处。**

**（2）求使最优基变量不改变的（即约束条件②的右端常数项）的取值范围。**

**（3）求使最优解不发生变化的（即目标函数中的价值系数）的取值范围。**

**（4）根据终表，求对偶问题的最优解。**

表2 初表

|  |  |
| --- | --- |
|  | -5 5 13 0 0 |
| b |  |
| 0 x4 20  0 | -1 1 3 1 0  12 4 10 0 1 |
|  |  |

表3 终表

|  |  |
| --- | --- |
|  | -5 5 13 0 0 |
| b |  |
|  | -1 1 1 0  16 0 -4 1 |
|  |  |

解：（1）

初表

|  |  |
| --- | --- |
|  | -5 5 13 0 0 |
| b |  |
| 0 20  0 90 | -1 1 3 1 0  12 4 10 0 1 |
|  | -5 5 13 0 0 |

终表

|  |  |
| --- | --- |
|  | -5 5 13 0 0 |
| b |  |
| 5 20  0 10 | -1 1 3 1 0  16 0 -2 -4 1 |
|  | 0 0 -2 -5 0 |

（2）变化，会影响b列取值，为保证最优基变量不变，则有：

得出：

（3）变化，只会影响的检验数，若最优解不发生变化，则：

。

（4）对偶问题的最优解：

解法1：对偶问题的最优解等于原问题松弛变量所对应检验数的相反数，故对偶问题最优解：。

解法2：。

|  |  |
| --- | --- |
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**四、（20分）已知某运输问题的产量、销量、及产地到销地的单位运价表如表4所示，试求最优的运输调拨方案。**

**表4**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **产量** |
| **1** | **10** | **20** | **5** | **9** | **10** | **5** |
| **2** | **2** | **10** | **8** | **30** | **6** | **6** |
| **3** | **1** | **20** | **7** | **10** | **4** | **2** |
| **4** | **8** | **6** | **3** | **7** | **5** | **9** |
| **销售** | **4** | **4** | **6** | **2** | **4** |  |

**解：先将不平衡运输问题转化为平衡运输问题，因为是产大于销，所以增加一列，即虚拟一个销地，其单位运价为0，销量为产量与销量的差额，即22-20=2.如下表**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | **产量** |
| **1** | **10** | **20** | **5** | **9** | **10** | **0** | **5** |
| **2** | **2** | **10** | **8** | **30** | **6** | **0** | **6** |
| **3** | **1** | **20** | **7** | **10** | **4** | **0** | **2** |
| **4** | **8** | **6** | **3** | **7** | **5** | **0** | **9** |
| **销售** | **4** | **4** | **6** | **2** | **4** | **2** |  |

**（3分）**

**用最小元素法，求得初始可行方案，如下表。初始解（3分）**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | **产量** |
| **1** |  | **1** |  | **2** |  | **2** | **5** |
| **2** | **2** | **3** |  |  | **1** |  | **6** |
| **3** | **2** |  |  |  |  |  | **2** |
| **4** |  |  | **6** |  | **3** |  | **9** |
| **销售** | **4** | **4** | **6** | **2** | **4** | **2** |  |

**计算检验数 第一次迭代（检验数的计算4分, 调整运量4分）**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | *ui* |
| **1** | |  | | --- | | **10** |   **-2** | **0**   |  | | --- | | **20** | | **-9**   |  | | --- | | **5** | | **0**   |  | | --- | | **9** | | **-6**   |  | | --- | | **10** | | **0**   |  | | --- | | **0** | | **0** |
| **2** | **0**   |  | | --- | | **2** | | **0**   |  | | --- | | **10** | | **4**   |  | | --- | | **8** | | **31**   |  | | --- | | **30** | | **0**   |  | | --- | | **6** | | **10**   |  | | --- | | **0** | | **-10** |
| **3** | **0**   |  | | --- | | **1** | | **11**   |  | | --- | | **20** | | **4**   |  | | --- | | **7** | | **12**   |  | | --- | | **10** | | **-1**   |  | | --- | | **4** | | **11**   |  | | --- | | **0** | | **-11** |
| **4** | **7**   |  | | --- | | **8** | | **-3**   |  | | --- | | **6** | | **0**   |  | | --- | | **3** | | **9**   |  | | --- | | **7** | | **0**   |  | | --- | | **5** | | **11**   |  | | --- | | **0** | | **-11** |
| *vj* | **12** | **20** | **14** | **9** | **16** | **0** |  |

**调整运量，得到新的调运方案**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | **产量** |
| **1** |  | **1** |  | **2** |  | **2** | **5** |
| **2** | **2** | **3** |  |  | **1** |  | **6** |
| **3** | **2** |  |  |  |  |  | **2** |
| **4** |  |  | **6** |  | **3** |  | **9** |
| **销售** | **4** | **4** | **6** | **2** | **4** | **2** |  |

**调整运量**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | **产量** |
| **1** |  | **0** | **1** | **2** |  | **2** | **5** |
| **2** | **2** | **4** |  |  |  |  | **6** |
| **3** | **2** |  |  |  |  |  | **2** |
| **4** |  |  | **5** |  | **4** |  | **9** |
| **销售** | **4** | **4** | **6** | **2** | **4** | **2** |  |

**再计算检验数**

**计算检验数 第二次迭代（2次-6次迭代 5分）**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | *ui* |
| **1** | |  | | --- | | **10** |   **-2** | **0**   |  | | --- | | **20** | | **0**   |  | | --- | | **5** | | **0**   |  | | --- | | **9** | | **3**   |  | | --- | | **10** | | **0**   |  | | --- | | **0** | | **0** |
| **2** | **0**   |  | | --- | | **2** | | **0**   |  | | --- | | **10** | | **13**   |  | | --- | | **8** | | **31**   |  | | --- | | **30** | | **9**   |  | | --- | | **6** | | |  | | --- | | **0** |   **10** | **-10** |
| **3** | **0**   |  | | --- | | **1** | | **11**   |  | | --- | | **20** | | **13**   |  | | --- | | **7** | | **12**   |  | | --- | | **10** | | **8**   |  | | --- | | **4** | | |  | | --- | | **0** |   **11** | **-11** |
| **4** | **-2**   |  | | --- | | **8** | | **-12**   |  | | --- | | **6** | | **0**   |  | | --- | | **3** | | **0**   |  | | --- | | **7** | | **0**   |  | | --- | | **5** | | **2**   |  | | --- | | **0** | | **-2** |
| *vj* | **12** | **20** | **5** | **9** | **7** | **0** |  |

**调整运费**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | **产量** |
| **1** |  |  | **1** | **2** |  | **2** | **5** |
| **2** | **2** | **4** |  |  |  |  | **6** |
| **3** | **2** |  |  |  |  |  | **2** |
| **4** |  | **0** | **5** |  | **4** |  | **9** |
| **销售** | **4** | **4** | **6** | **2** | **4** | **2** |  |

**计算检验数 第三次迭代**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | *ui* |
| **1** | |  | | --- | | **10** |   **10** | **12**   |  | | --- | | **20** | | **0**   |  | | --- | | **5** | | **0**   |  | | --- | | **9** | | **3**   |  | | --- | | **10** | | **0**   |  | | --- | | **0** | | **0** |
| **2** | **0**   |  | | --- | | **2** | | **0**   |  | | --- | | **10** | | **1**   |  | | --- | | **8** | | **19**   |  | | --- | | **30** | | **-3**   |  | | --- | | **6** | | |  | | --- | | **0** |   **-2** | **2** |
| **3** | **0**   |  | | --- | | **1** | | **11**   |  | | --- | | **20** | | **1**   |  | | --- | | **7** | | **0**   |  | | --- | | **10** | | **-4**   |  | | --- | | **4** | | |  | | --- | | **0** |   **-1** | **1** |
| **4** | **10**   |  | | --- | | **8** | | **0**   |  | | --- | | **6** | | **0**   |  | | --- | | **3** | | **0**   |  | | --- | | **7** | | **0**   |  | | --- | | **5** | | **2**   |  | | --- | | **0** | | **-2** |
| *vj* | **0** | **8** | **5** | **9** | **7** | **0** |  |

**调整运费**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | **产量** |
| **1** |  |  | **1** | **2** |  | **2** | **5** |
| **2** | **4** | **2** |  |  |  |  | **6** |
| **3** |  |  |  |  | **2** |  | **2** |
| **4** |  | **2** | **5** |  | **2** |  | **9** |
| **销售** | **4** | **4** | **6** | **2** | **4** | **2** |  |

**计算检验数 第四次迭代**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | *ui* |
| **1** | |  | | --- | | **10** |   **10** | **12**   |  | | --- | | **20** | | **0**   |  | | --- | | **5** | | **0**   |  | | --- | | **9** | | **3**   |  | | --- | | **10** | | **0**   |  | | --- | | **0** | | **0** |
| **2** | **0**   |  | | --- | | **2** | | **0**   |  | | --- | | **10** | | **1**   |  | | --- | | **8** | | **19**   |  | | --- | | **30** | | **-3**   |  | | --- | | **6** | | |  | | --- | | **0** |   **-2** | **2** |
| **3** | **4**   |  | | --- | | **1** | | **15**   |  | | --- | | **20** | | |  | | --- | | **7** |   **5** | **4**   |  | | --- | | **10** | | **0**   |  | | --- | | **4** | | |  | | --- | | **0** |   **3** | **-3** |
| **4** | **10**   |  | | --- | | **8** | | **0**   |  | | --- | | **6** | | **0**   |  | | --- | | **3** | | **0**   |  | | --- | | **7** | | **0**   |  | | --- | | **5** | | **2**   |  | | --- | | **0** | | **-2** |
| *vj* | **0** | **8** | **5** | **9** | **7** | **0** |  |

**调整运费**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | **产量** |
| **1** |  |  | **1** | **2** |  | **2** | **5** |
| **2** | **4** | **0** |  |  | **2** |  | **6** |
| **3** |  |  |  |  | **2** |  | **2** |
| **4** |  | **4** | **5** |  |  |  | **9** |
| **销售** | **4** | **4** | **6** | **2** | **4** | **2** |  |

**第五次迭代**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | *ui* |
| **1** | |  | | --- | | **10** |   **10** | **12**   |  | | --- | | **20** | | **0**   |  | | --- | | **5** | | **0**   |  | | --- | | **9** | | **6**   |  | | --- | | **10** | | **0**   |  | | --- | | **0** | | **0** |
| **2** | **0**   |  | | --- | | **2** | | **0**   |  | | --- | | **10** | | **1**   |  | | --- | | **8** | | **19**   |  | | --- | | **30** | | **0**   |  | | --- | | **6** | | |  | | --- | | **0** |   **-2** | **2** |
| **3** | **1**   |  | | --- | | **1** | | **12**   |  | | --- | | **20** | | |  | | --- | | **7** |   **2** | **1**   |  | | --- | | **10** | | **0**   |  | | --- | | **4** | | |  | | --- | | **0** |   **0** | **0** |
| **4** | **10**   |  | | --- | | **8** | | **0**   |  | | --- | | **6** | | **0**   |  | | --- | | **3** | | **0**   |  | | --- | | **7** | | **3**   |  | | --- | | **5** | | **2**   |  | | --- | | **0** | | **-2** |
| *vj* | **0** | **8** | **5** | **9** | **4** | **0** |  |

**调整运费**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | **产量** |
| **1** |  |  | **1** | **2** |  | **2** | **5** |
| **2** | **4** |  |  |  | **2** | **0** | **6** |
| **3** |  |  |  |  | **2** |  | **2** |
| **4** |  | **4** | **5** |  |  |  | **9** |
| **销售** | **4** | **4** | **6** | **2** | **4** | **2** |  |

**第6次迭代**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **销地**  **产地** | **甲** | **乙** | **丙** | **丁** | **戊** | **己** | *ui* |
| **1** | |  | | --- | | **10** |   **8** | **12**   |  | | --- | | **20** | | **0**   |  | | --- | | **5** | | **0**   |  | | --- | | **9** | | **4**   |  | | --- | | **10** | | **0**   |  | | --- | | **0** | | **0** |
| **2** | **0**   |  | | --- | | **2** | | **2**   |  | | --- | | **10** | | **3**   |  | | --- | | **8** | | **21**   |  | | --- | | **30** | | **0**   |  | | --- | | **6** | | |  | | --- | | **0** |   **0** | **0** |
| **3** | **1**   |  | | --- | | **1** | | **14**   |  | | --- | | **20** | | |  | | --- | | **7** |   **4** | **3**   |  | | --- | | **10** | | **0**   |  | | --- | | **4** | | |  | | --- | | **0** |   **2** | **-2** |
| **4** | **5**   |  | | --- | | **8** | | **0**   |  | | --- | | **6** | | **0**   |  | | --- | | **3** | | **0**   |  | | --- | | **7** | | **1**   |  | | --- | | **5** | | **2**   |  | | --- | | **0** | | **-2** |
| *vj* | **2** | **8** | **5** | **9** | **6** | **0** |  |

**由上表可知，调运方案为最优方案 运费为**

**Min z=90. (6分 结果正确)**

|  |  |
| --- | --- |
| **得分** | **评卷人** |
|  |  |

**五（15分）试建立如下问题的目标规划模型（只建模不求解）。**

**某工厂生产I,II两种产品，已知相关数据见表5，在工厂决策时，依次考虑如下的条件：**

1. **根据市场信息，产品I的销售量有下降的趋势，故考虑产品I的产量不大于产品II；**
2. **应尽可能充分利用设备台时，但不希望加班；**
3. **应尽可能达到并超过计划利润指标56元。**

**表5**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **I** | **II** | **拥有量** |
| **原材料（kg）** | **3** | **2** | **10** |
| **设备（hr）** | **1** | **2** | **12** |
| **利润（元/件）** | **8** | **10** |  |

**解：设 分别表示产品I, II的产量，其目标规划模型如下：**

****

|  |  |
| --- | --- |
| **得分** | **评卷人** |
|  |  |

**六、（15分）**有甲乙丙丁4个工人，要分别指派他们完成ABCD 不同的4项工作，每人做各项工作所消耗的时间如表6所示。应如何指派工作，才能使总的消耗时间最少？

表6

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **工作**  **工人** | **A** | **B** | **C** | **D** |
| **甲** | **5** | **10** | **7** | **4** |
| **乙** | **2** | **5** | **6** | **7** |
| **丙** | **3** | **13** | **11** | **7** |
| **丁** | **11** | **8** | **10** | **9** |

解：

设0-1型决策变量为，其中，=1表示指派第i个工人完成第j项工作，=0表示不指派第i个工人完成第j项工作，i,j=1,2,3,4。第1，2，3，4个工人分别代表甲乙丙丁。第1,2,3,4项工作分别代表ABCD四项工作。记表示第i个工人完成第j项工作所消耗的时间,i,j=1,2,3,4。则指派问题的数学模型为：

，

采用匈牙利法求解，步骤入下所示。

1. 将矩阵

|  |  |  |  |
| --- | --- | --- | --- |
| 5 | 10 | 7 | 4 |
| 2 | 5 | 6 | 7 |
| 3 | 13 | 11 | 7 |
| 11 | 8 | 10 | 9 |

的每行元素都减去该行的最小值，得到

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | 6 | 3 | 0 |
| 0 | 3 | 4 | 5 |
| 0 | 10 | 8 | 4 |
| 3 | 0 | 2 | 1 |

1. 将（1）中的结果矩阵的每列都减去该列的最小值，得到

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | 6 | 1 | 0 |
| 0 | 3 | 2 | 5 |
| 0 | 10 | 6 | 4 |
| 3 | 0 | 0 | 1 |

1. 在（2）中的结果矩阵的各行各列中寻找独立0元，并记以⓪。⓪所在行和列的其他0元素记为。得到

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | 6 | 1 | ⓪ |
| ⓪ | 3 | 2 | 5 |
|  | 10 | 6 | 4 |
| 3 |  | ⓪ | 1 |

1. 独立0元的个数为3<4，还未找到最优解，需要增加0元。将（3）中的结果矩阵中无⓪的行，标记。得到

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 | 6 | 1 | ⓪ |  |
| ⓪ | 3 | 2 | 5 |  |
|  | 10 | 6 | 4 |  |
| 3 |  | ⓪ | 1 |  |

1. 在（4）中的结果矩阵中标记的行中0元所在的列，标记为。得到

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 | 6 | 1 | ⓪ |  |
| ⓪ | 3 | 2 | 5 |  |
|  | 10 | 6 | 4 |  |
| 3 |  | ⓪ | 1 |  |
|  |  |  |  |  |

1. 在（5）的结果矩阵中，标记的列中⓪元所在的行，标记为。得到

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 | 6 | 1 | ⓪ |  |
| ⓪ | 3 | 2 | 5 |  |
|  | 10 | 6 | 4 |  |
| 3 |  | ⓪ | 1 |  |
|  |  |  |  |  |

1. 标记为的行中所有0元所在列都已被标记为。在（6）中的结果矩阵中，将无的行，以及标记为的列划线，得到

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 | 6 | 1 | ⓪ |  |
| ⓪ | 3 | 2 | 5 |  |
|  | 10 | 6 | 4 |  |
| 3 |  | ⓪ | 1 |  |
|  |  |  |  |  |

1. 选取（7）中的结果矩阵中未被划线覆盖的元素中的最小元素，也就是2。将标记的行的所有元素都减去最小元素，再将标记为的列的所有元素都加上最小元素。得到

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 3 | 6 | 1 | 0 |  |
| 0 | 1 | 0 | 3 |  |
| 0 | 8 | 4 | 2 |  |
| 5 | 0 | 0 | 1 |  |
|  |  |  |  |  |

1. 重复（3）的处理。在（8）的结果矩阵中重新寻找独立0元。得到

|  |  |  |  |
| --- | --- | --- | --- |
| 3 | 6 | 1 | ⓪ |
|  | 1 | ⓪ | 3 |
| ⓪ | 8 | 4 | 2 |
| 5 | ⓪ |  | 1 |

1. 独立0元的个数为4个，因此，找到最优解。

最优解为：其余都为0。最优值Z==21.

因此，应指派甲完成工作D，乙完成工作C，丙完成工作A，丁完成工作B。此时总耗时最少，为Z=21。