## Question 6 (10%)

Consider the examples on pages 11-15 in Lecture 13, two of the nurses (Mary and Jane) at Riverview UCC have decided to work part-time rather than full-time. They would like to work only two (consecutive) days per week. Because they would be part-time employees, salary and benefits per nurse-day for these nurses would be reduced to $160 on weekdays and $220 on weekend days. Riverview could hire an additional full-time nurse if needed. Should Riverview UCC agree to this request? If the clinic does agree, will additional nurses need to be hired? Assuming that part-time nurses and any new hires will accept any schedule and preferences for the remainder of the nurses are the same, what new schedule would you recommend for each nurse?

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| --- | --- |
| **Nurse** | **Schedule Assigned** |
| Mary | D |
| Anne | E |
| Susan | C |
| Tom | E |
| Cathy | B |
| Jane | A |

Objective: Minimize Salary = F + P, F is total full-time salary; P is total part-time salary.

P = 320(x12 + x13 + x14 + x15 + x16) + 240(x13 + x14 + x15 + x16 + x17) + 240(x14 + x15 + x16 + x17 + x11) + 240(x15 + x16 + x17 + x11 + x12) + 240(x16 + x17 + x11 + x12 + x13) + 240(x17 + x11 + x12 + x13 + x14) + 320(x11 + x12 + x13 + x14 + x15)

F = 220(x22 + x23) + 160(x23 + x24) + 160(x24 + x25) + 160(x25 + x26) + 160(x26 + x27) + 160(x27 + x21) + 220(x21 + x22)

xij, i = {1, 2}: 1 is full time, 2 is part time, j = {1, 2, 3, 4, 5, 6, 7}: Each represents the different combinations for days off for part time and full time

Subject to constraints:

* Sum of full-time and part-time workers >= the number of total workers required
  + Sunday: (x12 + x13 + x14 + x15 + x16) + (x22 + x23) >= 5
  + Monday: (x13 + x14 + x15 + x16 + x17) + (x23 + x24) >= 4
  + Tuesday: (x14 + x15 + x16 + x17 + x11) + (x24 + x25) >= 3
  + Wednesday: (x15 + x16 + x17 + x11 + x12) + (x25 + x26) >= 3
  + Thursday: (x16 + x17 + x11 + x12 + x13) + (x26 + x27) >= 3
  + Friday: (x17 + x11 + x12 + x13 + x14) + (x27 + x21) >= 4
  + Saturday: (x11 + x12 + x13 + x14 + x15) + (x21 + x22) >= 6
* Total number of part-time workers = 2 (Mary and Jane)
  + x21 + x22 + xx3 + x24 + x25 + x26 + x27 = 2
* Total number of full-time workers >= 4 (Anne, Susan, Tom, Cathy, plus any more required).
  + x11 + x12 + x13 + x14 + x15 + x16 + x17 >= 4
* Shift preferences: Mary had Shift D, and Jane had Shift A, so there were no constraints on Shifts A and D.
  + x12 = 1, Shift B (Cathy)
  + x13 = 1, Shift C (Susan)
  + x15 = 2, Shift E (Anne and Tom)
* All variables are integers, xij = int

Final Solution:

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| --- | --- |
| **Days off, xij** | **# of Employees** |
| Shift A, Sun Mon, x11 | 0 |
| Shift B, Mon Tue, x12 | 1 |
| Shift C, Tue Wed, x13 | 1 |
| Shift D, Wed Thu, x14 | 0 |
| Shift E, Thu Fri, x15 | 2 |
| Shift F, Fri Sat, x16 | 0 |
| Shift G, Sat Sun, x17 | 1 |
| Shift H, Sun Mon Tue Wed Thu, x21 | 1 |
| Shift I, Mon Tue Wed Thu Fri, x22 | 1 |
| Shift J, Tue Wed Thu Fri Sat, x23 | 0 |
| Shift K, Wed Thu Fri Sat Sun, x24 | 0 |
| Shift L, Thu Fri Sat Sun Mon, x25 | 0 |
| Shift M, Fri Sat Sun Mon Tue, x26 | 0 |
| Shift N, Sat Sun Mon Tue Wed, x27 | 0 |

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| Full Time Workers | 5 |
| Part Time Workers | 2 |

Objective: $7,460.00

Yes, Riverview should agree to this request. Originally, Riverview was spending $8,080.00/week on nurse salaries, but with the new plan, they should only be spending $7,460.00/week. They would just need to hire one more full-time worker. Since Mary had Shift D, and took Wednesday and Thursday off, she would take Shift I as a part-time worker. Jane had Shift A, and took Sunday and Monday off, so she would get Shift H since H is the one that gives both Sunday and Monday off in addition to Tuesday, Wednesday, and Thursday. The full-time worker would work during the weekdays and take the weekends off. Anne, Susan, Tom, and Cathy would all get to keep their preferred shifts. Below are the newly assigned shifts.

|  |  |
| --- | --- |
| **Nurse** | **Schedule Assigned** |
| Mary | I |
| Anne | E |
| Susan | C |
| Tom | E |
| Cathy | B |
| Jane | H |

## Question 7 (10%)

Develop your optimization model to solve the nurse scheduling problem based on the three shifts (8A.M.–4 P.M., 4 P.M. – 12, 12 – 8 A.M.) where the demand for nurses each day of the week (Sun, Mon, Tue, Wed, Thu, Fri, Sat) is: 7, 15, 13, 12, 10, 8, and 7. Each nurse works an 8-hour shift, with 5 days on and 2 consecutive days off. Your model should satisfy demand using the fewest number of nurses.Attribute scores reflect ratings of 1 through 10 (10 being best) with the exception of cost,delivery time, and product’s market share.

Since there are no shift preferences, you just treat it like a 24-hour shift problem, and then multiply the total workers by 3, since there are three 8-hour shifts. If you hire two workers that will take Sunday and Monday off, then you will hire 6 of them, 2 to work each 8-hour shift.

Objective: Minimize Total Workers, W = 3(x1 + x2 + x3 + x4 + x5 + x6 + x7)

Subject To:

* Sunday: x2 + x3 + x4 + x5 + x6 >= 7
* Monday: x3 + x4 + x5 + x6 + x7 >= 15
* Tuesday: x4 + x5 + x6 + x7 + x1 >= 13
* Wednesday: x5 + x6 + x7 + x1 + x2 >= 12
* Thursday: x6 + x7 + x1 + x2 + x3 >= 10
* Friday: x7 + x1 + x2 + x3 + x4 >= 8
* Saturday: x1 + x2 + x3 + x4 + x5 >= 7
* Integer: xi = int, i = {1, 2, 3, 4, 5, 6, 7}

Solution:

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| --- | --- | --- | --- |
| **Shift** | **Days off, xi** | **# of Employees** | **Times 3 Shifts** |
| A | Sun Mon, x1 | 0 | 0 |
| B | Mon Tue, x2 | 0 | 0 |
| C | Tue Wed, x3 | 2 | 6 |
| D | Wed Thu, x4 | 1 | 3 |
| E | Thu Fri, x5 | 4 | 12 |
| F | Fri Sat, x6 | 3 | 9 |
| G | Sat Sun, x7 | 5 | 15 |

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| --- | --- |
| Minimize Total Workers | 45 |
| Total Cost | $58,080.00 |

If I look to minimize the total cost, this is the solution. However, the problem asks not to consider cost. Regardless, this is a better solution because the cost is lower, and the amount of workers is the same.

|  |  |  |  |
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| **Shift** | **Days off, xi** | **# of Employees** | **Times 3 Shifts** |
| A | Sun Mon, x1 | 0 | 0 |
| B | Mon Tue, x2 | 0 | 0 |
| C | Tue Wed, x3 | 2 | 6 |
| D | Wed Thu, x4 | 1 | 3 |
| E | Thu Fri, x5 | 4 | 12 |
| F | Fri Sat, x6 | 0 | 0 |
| G | Sat Sun, x7 | 8 | 24 |

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| --- | --- |
| Minimize Total Workers | 45 |
| Total Cost | $57,360.00 |

Overall, you will have to hire 45 workers, and you can pay $57,360 per week. This considers the multiplication factor of 3, because if you need 5 nurses for Monday, then you need to have 15 nurses so 3 nurses can each work a particular shift.