1. (4 points) Answer the following questions based on the presentation “Building A Smarter Healthcare System”:

a. (2 points) List 3 IE tools that the healthcare system may use for improving the current system. Give an example of the application of each tool.

Answers may vary. One possible answer could be the following:

1) Simulation that enables the system analysis for different scenarios. Example: Study of doctors needed during each hour and each doctor working time assignment.

2) Control charts to track whether the current state of a variable is within the predetermined safety limits. Example: blood pressure tracking of hypertension patients.

3) Lean methodologies try to reduce possible resource waste. Example: purchasing of perishable drugs.

b. (2 points) The presentation shows the use of 3 IE tools to solve the “Urgent Care Patient Forecasting and Staffing Optimization” case. To which of these 3 tools result, the system outputs are more sensitive? Explain.

The system outputs are more sensitive to the results of the patients forecasting. Because the other two tools, optimization and simulation, use the patient forecasting result as an input. If the forecast is not accurate, the results from optimization and simulation are not showing the current situation. Thus it is hard to have good advices to improve the current state.
2. (7 points) Answer the following questions based on the presentation “Optimization in Intensity Modulated Radiation Therapy (IMRT)“:

   a. (5 points) Following the notations of the presentation, please formulate the optimization problem with the objective to minimize the dose received by the critical voxels. Please write down the objective function and all the constraints considered in the presentation.

   \[
   \min \sum_{i \in C} z_i \\
   \text{s.t. } z_i = \sum_{j \in J} D_{ij} x_j \quad \forall i \in I \\
   z_i \geq d_T \quad \forall i \in T \\
   z_i \leq d_C \quad \forall i \in C \\
   x_j \geq 0 \quad \forall j \in J
   \]

   b. (1 points) Why does the presentation recommend a scoring approach in the beam angle selection instead of solving the entire optimization problem?

   Because the entire optimization problem for selecting the best combination of beamlets and its beam angle is very big; and it’s impossible to solve it within reasonable time. The scoring approach tries to simplify this problem into a simple beam angle selection. It’s necessary to calculate first the total dose received by the tumor and by the critical organs for each beam angle. Then we select the beam angles such that the total dose received by tumor voxels is maximized and the total dose received by critical organs is restricted by some threshold.

   c. (1 points) We have seen in class that one row of 3 beamlets leads to 6 possible shapes for consideration. If there are 4 beamlets per row, how many shapes should the optimization problem consider?

   There are 10 shapes to be considered in the optimization problem when there are 4 beamlets per row.
3. (3 points) Answer the following questions based on the presentation “Debris Management Operations”:

a. (1 points) The presentation considers 3 different network shapes, why is the solution time for the problems on the complete grid network longer than the solution time of the incomplete grid network?

The problem objective is to connect all the nodes. In the incomplete grid network, a lot of nodes not in the border have only one way to get connected, thus reduces the number of nodes and choices to be considered in the optimization problem. However, for the complete grid network, all nodes not in the border have 4 ways to get connected, and the optimization model has to consider all connection possibilities to find the best solution. Consequently, the incomplete grid network systems are solved within shorter time than the complete grid network systems.

b. (2 points) What is the method recommended in the presentation to prioritize the connection of some zones over the others? What is the condition that makes this method work?

The presentation recommends a differentiation in penalty cost of each node to prioritize the connection of some nodes over the others. The higher priority nodes has higher penalty cost than the lower priority ones. This method works when the objective function of the optimization problem is to minimize the system’s penalty cost, and the cost of all the arcs in consideration is homogenous.

4. (3 points) Answer the following questions based on the following paper:


a. (1 points) What are the 9 main steps of a POD treatment?

The main 9 steps of a POD treatment are: triage, orientation, forms area, staff assistance in completion of forms, forms review, further screening and medical counseling, quality assurance, vaccination and exit review.
b. (2 points) What is the heuristic used by the Optimization Manager of? Explain briefly how this heuristic works.

The RealOpt Optimization Manager uses a hybrid heuristic algorithm. This hybrid heuristic algorithm is a combination of greedy algorithm and local search. First, the algorithm assigns number of workers at each station by greedy algorithm, considering as input the estimated queue length at each station. And the queue length of each station is calculated based on the service time distribution at each station. Then the algorithm observes the outcome of the simulation based on the workers assignment previously defined, and adjusts the workers assignments using local search.

5. (4 points) Answer the following questions based on the presentation “Catch-up Scheduling for Childhood immunization”

a. (2 points) Explain the motivation behind each term of the objective function (Page 10 of the presentation, slide number 20). Should we maximize this objective function or minimize it?

\[
\sum_{v \in \tau} x_v - \sum_{v \in \mathcal{V}} \sum_{k=1}^{n(v)} \sum_{m \neq v,k} M^{x,v,k} y_{v,k,t} + \sum_{v \in \mathcal{V}} \sum_{k=1}^{n(v)} d_{v,k} + \sum_{v \in \mathcal{V}} \sum_{k=1}^{n(v)-1} g_{v,k}
\]

This objective function should be minimized.

1: Number of visits to the medical center within the studied time horizon. It is positive because it should be minimized.

2: Number of vaccinations taken at each visit during the considered time horizon. It needs to be maximized, therefore it is negative.

3: Penalty cost when there is a delay in taking a scheduled dose of vaccination. It is positive because it should be minimized.

4: Penalty cost when a recommended gap between doses of a vaccination is violated. It is positive because it should be minimized.
b. (2 points) What kind of dominance relationship exists between the following three schedules? Explain.

Between X and Y: Not comparable, because there are fewer doses administered for some vaccine in schedule X, but X has the critical dose administered earlier than schedule Y.

Between X and Z: Not comparable, same reason as above.

Between Y and Z: Schedule Z dominates Y. Because they have same number of doses administered for each vaccine, the critical dose is administered earlier in schedule Z than Y, and the total delay in schedule Z is less than the total delay in schedule Y.

Note: If you want to submit your homework electronically, please send it to ytlee1@gatech.edu. If you want to submit a hardcopy, please bring it to class.