Lecture 6

1. There are five runners qualified to run the 800 x 4 relay, but only four slots are needed for the race. This means one runner will become an alternate in the event any of the others cannot run the day of the track meet. The following table contains the expected times for each runner based on the data from the order of them for the upcoming state meet.

Runner\Leg	Leg 1	Leg 2	Leg 3	Leg 4
Fowler	2.20	2.18	2.35	2.29
Clark	2.19	2.23	2.25	2.39
Norman	2.22	2.30	2.29	2.42
Houston	2.23	2.36	2.40	2.45
Massey	2.25	2.40	2.50	2.59

Some runners are stronger at the start or finish and others are better in the middle. The assignment program will help to determine which runners to place where. The goal is to have an overall time of 9.05 or less to have a chance at first place.

a. Formulate the problem as an assignment problem.
b. Create an Excel template and apply Solver to select the runners and their leg assignments in the relay. Do you think the track coach will be able to reach the goal of having an overall time below 9.05?
c. Assume that Fowler will not be able to compete due to an injury during the practice. Rerun the model to assign the best leg assignments for the remaining four runners. Will the coach still be able to reach the overall time goal?

2. Consider the toy manufacturing company producing truck toys and car toys. Each production lot of truck toys requires six pounds of plastic, ten hours of labor, and ten hours of machine time. A car toy lot requires eight pounds of plastic, eight hours of labor, and four hours of machine time. There are 72 pounds of plastic available, 80 hours of labor available, and 60 hours of machine time for each day. The profit for either toy is $1,000 per. lot.
Assuming that the manufacturer cannot produce fractions of toy lots, adjust the linear programming formulation and solve the problem graphically. Answer the following questions:

a. What is the optimal number of toy truck lots and toy car lots to be purchased each day?
b. What is the value of the objective function (total profit) for the previous solution?
c. Identify binding and not binding constraints for the optimal solution.

3. Consider the same toy manufacturing company, but suppose the manager wants to consider several priorities:
   • Goal 1: The company should use the available plastic completely (P = 1,000).
   • Goal 2: The company should not underutilize labor and machine hours available (P = 200).
   • Goal 3: The company should minimize production cost (P = 500).
   The cost of producing a lot of toy trucks is $700T + 40T^2 + 1{,}000$ and the cost of producing a lot of toy cars is $200C + 20C^2 + 1{,}500$. There is a total budget of $5,000 per week. The profit for either toy is $500 per lot.
   a. Formulate and solve the model as a goal programming model.
   b. Add the requirement that the solution values be integers and solve the integer goal programming model.
   c. Compare the results from steps a and b and provide managerial recommendations for the operations manager.

4. Consider the nonlinear programming model. The Excel file *ch6_P6chair_table_solution* has the template and the final solution. The following is the problem description for the model:
   A chair manufacturer wants to determine how many units for each category the company should produce during the next month. Each single-seat chair needs an average of $30 of raw materials and takes an average of eight hours to make. Each multiple-seat chair needs an average of $70 of raw materials and takes an average of ten hours to make. There are 10,000 hours available and a $20,000 budget to purchase raw materials each month. The fixed cost per unit decreases when the production volume increases and the Excel file *ch6_P6chair_table_solution* contains the cutoff points for the profit.
   Screen the Excel file to understand the usage of VLOOKUP function to model decreasing costs. Consider changing available hours to 5000 only.

5. Integer programming models have an objective function to be optimized, a set of constraints to be satisfied, and a set of constraints that forces some or all decision variables to be integers.
    a. True
    b. False

6. 0–1 linear programming is a special case of integer programming.
    a. True
    b. False

7. When solving an integer linear programming model, the value of the objective function will not be better than the objective function of the respective non-integer model.
    a. True
    b. False

8. In the assignment model, the number of resources and tasks must always be equal.
    a. True
    b. False

9. In a mathematical programming model, the divisibility assumption allows decision variables to take:
    a. Integer values.
    b. Fractional values.
    c. Negative values.
    d. All of those

10. Which of the following definitions of decision variables requires the decision maker to not enforce an integer solution?
    a. The number of houses to build in a new neighborhood
    b. The number of pounds of products to be produced in a week’s time
    c. The number of airplanes to produce during a year
    d. All of those

11. Integer programming models have the same structure as:
    a. Linear programming.
    b. Nonlinear programming.
    c. Goal programming.
    d. All of those

12. Which of the following constraints belongs to an integer programming model but not necessarily to a linear programming model?
    a. Non-negativity constraints
    b. Integer constraints
    c. Non-integer constraints
    d. All of those

13. Which of the following constraints belongs to an integer programming model, but not necessarily to a goal programming model?
    a. An objective function
    b. Integer constraints
    c. System constraints
    d. Both a and b

14. Which of the following is not a type of integer programming model?
    a. An all-integer programming model
    b. A mixed-integer programming model
    c. A linear integer programming model
    d. All of those are types of integer programming models.

15. Which of the following is not a type of integer nonlinear programming model?
    a. An all-integer nonlinear programming model
    b. A mixed-integer nonlinear programming model
    c. A nonlinear integer goal programming model

d. All of those are types of integer programming models.

16. Nonlinear integer programming models offer additional challenges for solution algorithms because:
    a. The values of reduced gradients are valid only at the point of the optimal solution.
    b. The values of Lagrange multipliers are valid only at the point of the optimal solution.
    c. The generalized reduced gradient algorithm cannot differentiate local and global optima.
    d. All of those

17. 0–1 linear programming is a special case of:
    a. Integer programming.
    b. Nonlinear programming.
    c. Nonlinear integer programming.
    d. All of those

18. Which of the following is a result that the decision maker should anticipate when solving an integer linear programming model with a maximization objective?
    a. The value of the objective function will not be less than the objective function of the non-integer model.
    b. The value of the objective function will be greater than the objective function of the non-integer model.
    c. The value of the objective function will not be greater than the objective function of the non-integer model.
    d. All of those

19. Which of the following is a result that the decision maker should anticipate when solving an integer nonlinear programming model with a minimization objective?
    a. The value of the objective function will not be less than the objective function of the non-integer model.
    b. The value of the objective function will be greater than the objective function of the non-integer model.

c. The value of the objective function will not be greater than the objective function of the non-integer model.
d. All of those

20. Which of the following is a result that the decision maker should anticipate when solving an integer nonlinear programming model with a maximization objective?
    a. The value of the objective function will not be less than the objective function of the non-integer model.
    b. The value of the objective function will be greater than the objective function of the non-integer model.
    c. The value of the objective function will not be greater than the objective function of the non-integer model.
    d. All of those

21. In the assignment method, the decision maker seeks to assign:
    a. Each available resource to a specific set of tasks.
    b. One resource to only one task.
    c. Several available resources to one set of tasks.
    d. Several available resources to only one task.

22. Which of the following is a context that may require the use of the assignment method?
    a. There are m machines and n workers to be assigned at the beginning of production period ($m \neq n$).
    b. There are m machines and n workers to be assigned at the beginning of production period ($m = n$).
    c. Both a and b
    d. Neither a nor b