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**RESOURCE MANAGEMENT TECHNIQUES**

**UNIT- 3**

**1.What is Non-Linear Programming? Importance of Non-Linear Programming.**

Answer:

Nonlinear Programming (NLP) is the process of solving an optimization problem where some of the constraints or the objective function are nonlinear. Let *n*, *m*, and *p* be positive integers. Let *X* be a subset of *Rn*, let *f*, *gi*, and *hj* be real valued function on *X* for each *i* in {*1*, …, *m*} and each *j* in {*1*, …, *p*}, with at least one of *f*, *gi*, and *hj* being nonlinear.

A nonlinear minimization problem is an optimization problem of the form

Minimize f(x)

Subject to gi(x) <=0 for each i = 1,2,…m

hj(x) =0 for each j = 1,2,….p

{\displaystyle {\begin{aligned}{\text{minimize }}&f(x)\\{\text{subject to }}&g\_{i}(x)\leq 0{\text{ for each }}i\in \{1,\dotsc ,m\}\\&h\_{j}(x)=0{\text{ for each }}j\in \{1,\dotsc ,p\}\\&x\in X.\end{aligned}}}

A nonlinear maximization problem is defined in a similar way.

Non-linear programming methods assure obtaining, with certain precision, local minimum in the search space while the qualify use of metaheuristics could assure to obtain close to the global optimal solution, or populations of them close to the optimal.

**2. Types of Non-Linear Programming.**

ollows: i). NLP technique is successfully applied to the overall cost minimization of transformer active and

mechanical part, ii). Transformer design variables such as the conductors‟ cross-section and windings are

added to the optimization algorithm for an enlarged and transverse optimum transformer designs. The

proposed methods find acceptable optimum transformer design by minimizing either the overall transformer

material cost (i.e. the transformer active part cost plus mechanical part cost) or the overall transformer

materials and operating cost taking into consideration proper loss evaluation factors, while simultaneously

satisfying all the constraints imposed by international standards and transformer user needs, instead of

focusing on the optimization of only one parameter of transformer performance (e. g no-load losses or short

circuit impedance). Using the proposed technique, a graphic user interface (GUI) software package is

developed that combine‟s transformer design with analysis, optimization and visualization tools, useful for

both design optimization and educational use. The technique is applied to the design of power transformers

of several ratings and loss. Categories and the results are compared with transformer design optimization

method (which is already used by transformer industry), resulting to significant cost savings.

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1.UNCONSTRAINED OPTIMIZATION IN ONE DIMENSION:

Here we begin by considering a significantly simplified (but nonetheless important) nonlinear programming problem, i.e., the domain and range of the function to be minimized are one-dimensional and there are no constraints. A necessary condition for a minimum of a function was developed in calculus and is simply f’(x) = 0.

Note that higher derivative tests can determine whether the function is a max or a min, or the value f(x + δ) may be compared to f(x).

Note that if we let g(x) = f’(x) then we may convert the problem of finding a minimum or maximum of a function to the problem of finding a zero.

1. Bisection Algorithm:

Let x ∗ be a root, or zero, of g(x), i.e., g(x\*) = 0. If an initial bracket [a, b] is known such that x ∗ ∈ [a, b], then a simple and robust approach to determining the root is to bisect this interval into two intervals [a, c] and [c, b] where c is the midpoint, i.e., c = (a + b)/2

If g(a)g(c) < 0

then we conclude x ∗ ∈ [a, c]

while if g(b)g(c) < 0

then we conclude x ∗ ∈ [b, c]

This process may now be iterated such that the size of the bracket (as well as the actual error of the estimate) is being divided by 2 every iteration.

1. Newton’s Method:

Note that in the bisection method the actual value of the function g(x) was only being used to determine the correct bracket for the root. Root finding is accelerated considerably by using this function information more effectively.

For example, imagine we were seeking the root of a function that was a straight line, i.e., g(x) = ax + b and our initial guess for the root was x0. If we extend this straight line from the point x0 it is easy to determine where it crosses the axis, i.e., ax1 + b = 0 so x1 = −b/a.

Of course, if the function were truly linear then no first guess would be required. So now consider the case that g(x) is nonlinear but may be approximated locally about the point x0 by a line. Then the point of intersection of this line with the x-axis is an estimate, or second guess, for the root x ∗ .

The linear approximation comes from Taylor’s theorem,

i.e., g(x) = g(x0) + g’ (x0)(x – x0) + 1/ 2 g ‘’(x0)(x – x­0) 2 + . . .

So the linear approximation to g(x) about the point x0 can be written l(x) = g(x0) + g’ (x0)(x − x0)

If we take x1 to be the root of the linear approximation we have

l(x1) = 0 = g(x0) + g’(x0)(x1 – x0)

Solving for x1 gives x1 = x0 − g(x0)/g’(x0) or at the nth iteration xn+1 = xn − g(xn)/g’(xn)

The iteration above is for determining a zero of a function g(x). To determine a maximum or minimum value of a function f we employ condition that f 0 (x) = 0. Now the iteration is modified as as xn+1 = xn – f’ (xn)/ f’’(xn)

2.UNCONSTRAINED OPTIMIZATION IN HIGHER DIMENSION:

Now we consider the problem of minimizing (or maximizing) a scalar function of many variables, i.e., defined on a vector field. We consider the extension of Newton’s method presented in the previous section as well as a classical approach known as steepest descent.

a. Taylor Series in Higher Dimensions

b. Newton’s Method

c. Steepest Descent Method

3.CONSTRAINED OPTIMIZATION AND LAGRANGE MULTIPLIERS:

Some constrained optimizations are

a. One Equality Constrained

b. Several Equality Constrained

c. Inequality Constrained

**3.Applications of Non-Linear Programming.**

1.Application of Nonlinear Programming for Optimization of Nutrient Requirements for Maximum Weight Gain in Buffaloes:

Nonlinear effects of nutrient ingredients are introduced as an approach closer to the true effects of nutrient ingredients. A nonlinear model is developed to take consideration of nutrient ingredients more effectively. The nonlinear model is introduced in order to maximize the weight gain in buffalo by the optimal use of feed ingredients. Data from a variable caloric density study for buffalo is fitted to nonlinear objective function expression for weight gain of the animal in terms of feed ingredients. National Research Council requirements are introduced as constraints for mathematical model. Proposed model with nonlinear programming measures its performance and gives a comparative result with linear programming models. Thus the study is an attempt to develop a nonlinear programming model for optimal planning and best use of nutrient ingredients. Introduction of nonlinear programming to optimize yield and minimize feed cost in buffalo feed formulation may lead to better approximation as compared to those of linear cases. Present study is carried out to extend the work by inclusion of this nonlinear relation. Leading to the same guideline a ration can be formulated using all its nutrient ingredients simultaneously at the optimum level. In this paper, it is envisaged to develop a mathematical model using non-linear programming to take simultaneous effects of all nutrient ingredients and the diet is optimized by using Kuhn- Tucker conditions. This result is also compared to than that of linear programming formulation of the model.

#### 1. Weightage of Variables

First of all, linear relationship for dependent and independent variables is formulated to decide the weightage of the variables. Assuming a linear relationship between weight gain of buffaloes and intake of DM, CP and TDN, the weightage of these variables was decided.

Using least square method, the relationship is depicted in the following equation which describes the weightage of the variables x1, x2 and x3.

|  |  |
| --- | --- |
|  | (1) |

#### 2. Relationship between Variables

By using least square method, the relations between y and x1, y and x2, y and x3 of different degrees were established and then by using F-test the relation of best fit was decided. Applying the F-test, the following most appropriate relationship between the variables were derived:

|  |  |
| --- | --- |
|  | (2) |

#### 3. Formulation of Objective Function

The objective function was established by using the appropriate relations of the variables x1, x2, x3 according to their weightage on weight gain of the buffalo calves. The weightage with respect to total effect of this weightage was considered:

|  |  |
| --- | --- |
|  | (3) |

#### 4. Constraints

The constraints according to feeding standards on the above-mentioned variables according to feeding standards of NRC (1981) were applied

|  |  |
| --- | --- |
|  | (4) |

#### 5. Problem Defined

The main problem is formulated to maximise weight gain of the animal:



subject to:

|  |  |
| --- | --- |
|  | (5) |

#### 6. Solution of the Problem

Introducing Kuhn-Tucker conditions, the weight gain of the buffalo calves could be maximized as:



Using Kuhn-Tucker conditions, the following set of equations were obtained for optimal solutions:













x1 ≤ 396.311

x2 ≤ 37.708

x3 ≤ 368.1687036



Solving these equations the optimum values of the three nutrients is found out to maximize the body weight gain. Accordingly we have:

x1= 381.3028, x2= 7.708, x3= 368.1687036 g/kg W0.75It also gives, λ1= 0.393301399, λ2= 0.027548012 which satisfied all the conditions.

The problem is also formulized and solved by simplex method and it gives,

x1= 396.311, x2= 37.708, x3= 368.1687036 g/kg W0.75

Comparison shows that by linear programming result is obtained at corner points of feasible area and optimization is at comparatively at higher values of nutrient ingredients. This comparison represents that non-linear programming is better way to take simultaneous effect of all nutrient ingredients together and maximize the weight gain in animal with optimized value of nutrient ingredients.

**UNIT-4**

**1.What is Integer Programming?**

Answer:

An integer programming problem (ILP) is a mathematical optimization or feasibility program in which some or all of the variables are restricted to be integers.

An integer linear program in canonical form is expressed as:

Maximize cT x

Subject to Ax<=b,

x>=0,

and x € Z

{\displaystyle {\begin{aligned}&{\text{maximize}}&&\mathbf {c} ^{\mathrm {T} }\mathbf {x} \\&{\text{subject to}}&&A\mathbf {x} \leq \mathbf {b} ,\\&&&\mathbf {x} \geq \mathbf {0} ,\\&{\text{and}}&&\mathbf {x} \in \mathbb {Z} ^{n},\end{aligned}}}

and an ILP in standard form is expressed as

maximize cT x

subject to Ax +s =b,

x>=0, s>=0,

and x € Z

{\displaystyle {\begin{aligned}&{\text{maximize}}&&\mathbf {c} ^{\mathrm {T} }\mathbf {x} \\&{\text{subject to}}&&A\mathbf {x} +\mathbf {s} =\mathbf {b} ,\\&&&\mathbf {s} \geq \mathbf {0} ,\\&&&\mathbf {x} \geq \mathbf {0} ,\\&{\text{and}}&&\mathbf {x} \in \mathbb {Z} ^{n},\end{aligned}}}

where {\displaystyle \mathbf {c} ,\mathbf {b} }c,bc, b are vectors and A{\displaystyle A} is a matrix, where all entries are integers. As with linear programs, ILPs not in standard form can be converted to standard form  by eliminating inequalities, introducing slack variables (s{\displaystyle \mathbf {s} }ss) and replacing variables that are not sign-constrained with the difference of two sign-constrained variables.

**2. Types of Integer Programming.**

Answer:

There are three types of IP models:

1. In mixed integer programming, only some of the variables are restricted to integer values.
2. In pure integer programming, all the variables are integers.
3. In binary integer programming or 0-1 integer programming, all the variables are binary (restricted to the values 0 or 1).

Mixed Integer Programming:

The problems most commonly solved by the Gurobi Parallel Mixed Integer Programming solver are of the form:

|  |  |
| --- | --- |
| Objective: | minimize cT x |
| Constraints: | A x = b (linear constraints) |
|  | l ≤ x ≤ u (bound constraints) |
|  | some or all xj must take integer values (integrality constraints) |

The integrality constraints allow MIP models to capture the discrete nature of some decisions.  For example, a variable whose values are restricted to 0 or 1, called a binary variable, can be used to decide whether or not some action is taken, such as building a warehouse or purchasing a new machine.

The Gurobi MIP solver can also solve models with a quadratic objective and/or quadratic constraints:

|  |  |
| --- | --- |
| Objective: | minimize xT Q x + qT x |
| Constraints: | A x = b (linear constraints) |
|  | l ≤ x ≤ u (bound constraints) |
|  | xT Qi x + qiT x ≤ bi (quadratic constraints) |
|  | some or all x must take integer values (integrality constraints) |

MIP models with a quadratic objective but without quadratic constraints are called Mixed Integer Quadratic Programming (MIQP) problems. MIP models with quadratic constraints are called Mixed Integer Quadratically Constrained Programming (MIQCP) problems. Models without any quadratic features are often referred to as Mixed Integer Linear Programming (MILP) problems.

Mixed Integer Programming generally solved using Branch and Bound algorithm.

Binary Integer Programming:

Binary Integer Programming (BIP) is an approach to solve a system of linear inequalities in binary unknowns (0 or 1 in what follows). Integer programming has been studied in mathematics, computer science, and operations research for more than 40 years. It has been successfully applied to solve a huge number of large-scale combinatorial problems.

The general form of an integer linear programming problem is max { c T x | Ax ≤ b, x ∈ Zn } (1.1) with a real matrix A of a dimension m by n, and vectors c ∈ Rn , b ∈ Rm, c T x being the scalar product of the vectors c and x. If the system Ax ≤ b includes the constraints 0 ≤ x ≤ 1, we get a binary integer linear programming problem (BIP). A vector x\* in Zn with Ax\* ≤ b is called a feasible solution. If moreover, c T x\* = max { c T x | Ax ≤ b, x ∈ Zn }, then x\* is called an optimal solution and c T x\* the optimal value.

We use specialized branch and bound method for solving BIP known as Balas Additive Algorithm.

The keys how Balas Additive Algorithm works lies in its special structure:

1. The objective function is minimization and all of the coefficients are nonnegative, so we would prefer to set all the variables to zero to give the smallest value of Z.
2. If we cannot set all the variables to zero without violating one or more constraints, then we prefer to set all the variables that has smallest index 1. This is because variables are ordered so that those earlier in the list increase by Z by smallest amount.

**3. Applications of Integer Programming.**

Answer:

# 1.Integer programming models for mid-term production planning for high-tech low-volume supply chains:

Mid-term production planning (6 to 24 months) allocates the capacity of production resources to different products over time and coordinates the associated inventories and material inputs so that known or predicted demand is met in the best possible manner. High-tech low-volume industries can be characterized by the limited production quantities and the complexity of the supply chain. To model this, we introduce a mixed integer linear programming model that can handle general supply chains and production processes that require multiple resources. Furthermore, it supports semi-flexible capacity constraints and multiple production modes.

Because of the integer production variables, size of realistic instances and complexity of the model, this model is not easily solved by a commercial solver. Applying Benders’ decomposition results in alternative capacity constraints and a second formulation of the problem. Where the first formulation assigns resources explicitly to release orders, the second formulation assures that the available capacity in any subset of the planning horizon is sufficient. Since the number of alternative capacity constraints is exponential, we first solve the second formulation without capacity constraints. Each time an incumbent is found during the branch and bound process a maximum flow problem is used to find missing constraints. If a missing constraint is found it is added and the branch and bound process is restarted. Results from a realistic test case show that utilizing this algorithm to solve the second formulation is significantly faster than solving the first formulation.

2.Integer Programming in Telecommunication:

The cellular telecommunication network design aims to define and dimension the cellular telecommunication system topology in order to serve the voice and/or data traffic demand of a particular geographic region. In this article, we introduce a novel model that addresses the cellular system design problem in a complete fashion. We propose a linear mixed-integer programming model that gathers together into the same model the base station location problem, the frequency channel assignment problem and the base station connection to the fixed network. The purpose of unifying these three problems in the same model is to treat the trade-offs among them providing a higher quality solution to the cellular system design. We still present some computational analyses in order to evaluate the model tradeoffs and its time complexity. In conclusion, we mention our current work towards an effective technique to solve the proposed model.

**UNIT-5**

**1.What is Queuing Theory? Importance of Queuing Theory.**

Answer:

Queuing theory is the study of congestion and waiting in line. The theory can help with creating an efficient and cost-effective workflow, allowing the user to improve traffic flow. Queuing theory assesses two key aspects: customer arrival at the facility and service requirements.

Queuing are the most frequently encountered problems in everyday life. For example, queue at a cafeteria, library, bank, etc. Common to all of these cases are the arrivals of objects requiring service and the attendant delays when the service mechanism is busy..

Queuing theory helps to describe features of the queue, like average wait time, and provides the tools for optimizing queues. From a business sense, queuing theory informs the construction of efficient and cost-effective workflow systems.

**2.Models of QT. Briefly explained.**

Answer:

Queuing Model:

It is a suitable model used to represent a service oriented problem, where customers arrive randomly to receive some service, the service time being also a random variable.

Arrival:

The statistical pattern of the arrival can be indicated through the probability distribution of the number of the arrivals in an interval.

Service Time:

The time taken by a server to complete service is known as service time.

Server:

It is a mechanism through which service is offered.

Queue Discipline:

It is the order in which the members of the queue are offered service. i.e, It is the rule accordingly to which customers are selected for service when queue has been formed.

The most common disciplines are

1. First come First services(FCFS)

2. First in First Out(FIFO)

3. Last in First out(LIFO)

4. Selection for service in Random order(SIRO)

Poisson Process:

It is a probabilistic phenomenon where the number of arrivals in an interval of length t follows a Poisson distribution with parameter t, where is the rate of arrival.

Queue (Waiting lines):

A group of items waiting to receive service, including those receiving the service, is known as queue.

Waiting time in queue (Wq):

Time spent by a customer in the queue before being served.

Waiting time in the system (WS):

It is the total time spent by a customer in the system. It can be calculated as follows:

Waiting time in the system = Waiting time in queue + Service time

Queue length (Lq):

Number of persons in the system at any time Average length of line. The number of customers in the queue per unit of time.

Average idle time (p0):

The average time for which the system remains idle Bulk Arrivals If more than one customer enters the system at an arrival event, it is known as bulk arrivals. Note that bulk arrivals are not embodied in the models of the subsequent sections.

Queuing System:

A queuing system can be completely described by The input (or arrival Patten) The service mechanism (or service pattern) The queuing discipline Customer’s behaviour.

There are four types of queuing model:

1. M/M/1 Queuing Model
2. M/M/C Queuing Model
3. M/M/1/N Queuing Model
4. M/M/C/N Queuing Model
5. **Applications of QT.**

# 1.Analysis of an M/M/*C*  Queueing System with Impatient Customers and Synchronous Vacations:

An queueing M/M/C system with impatient customers and a synchronous vacation policy. Customers arrive according to a Poisson process at rate λ. The service is provided by servers, who serve the customers on a first-come first-served (FCFS) basis. The service time of each customer is exponentially distributed with mean 1/µ.

The multiple synchronous vacation policy is described as follows. When the server finishes serving a customer and finds the system empty, all servers immediately leave for a vacation. If servers return from a vacation to find an empty queue, they immediately leave for another vacation; otherwise, they return to serve the queue. The duration of a vacation is exponentially distributed with mean 1/Υ.

During the vacation, customers are impatient. That is, an arriving customer who finds that all servers are on vacation activates an “impatience timer" T, which is exponentially distributed with mean 1/ƺ. If the customer’s service has not been completed before the customer’s timer expires, the customer abandons the queue and never returns.

2. Applications of Queuing Theory in the Tobacco Supply:

There are many problems in the supply of goods. In the company, both in the supply of goods in the form of raw materials, as well as in the supply of goods in the form of the final product to the consumer. Queue does not need to be eliminated at all, or did not need to develop the facility as possible. The firm should be able to think as a result of the increasingly long queues. The firm should be able to set up to achieve optimal conditions with a row of fairly short queue. That is important for supplier to minimize loss. PT XYZ is a procurement company of Madura tobacco raw materials for other company. PT XYZ obtain supplies of dried tobacco (chopped Madura) of the tobacco collectors known as bandol. Tobacco supply from the bandol is done with sorting systems in order to obtain tobacco in accordance with company standards. Long queue often occurs when tobacco sorting is done. Time obscurity of Bandol experienced to be served and to wait during the sorting. It certainly can make cost and time impact for bandol. According to Levin (2002) and Bustani (2005), there is a way to eliminate the waiting time. The company can set a server so that there will be no queuing, but it is clearly detrimental to the company by increasing salaries of the employees.