en_question

A factory produces two types of food, I and II, and currently has 50 skilled workers. It is known that one skilled worker can produce $10 \ \mathrm{kg} / \ \mathrm{h}$ of food I or $6 \ \mathrm{kg} / \ \mathrm{h}$ of food II. According to contract bookings, the weekly demand for these two foods will rise sharply, as shown in Table 1-11. Therefore, the factory has decided to train 50 new workers by the end of the 8th week. It is known that a worker works $40 \ \mathrm{h}$ per week, and a skilled worker can train up to three new workers in two weeks (during the training period, both the skilled worker and the trainees do not participate in production). The weekly wage of a skilled worker is 360 yuan, the weekly wage of a trainee during the training period is 120 yuan, and after training, the wage is 240 yuan per week, with the same production efficiency as skilled workers. During the transition period of training, many skilled workers are willing to work overtime, and the factory has decided to arrange some workers to work $60 \ \mathrm{h}$ per week, with a weekly wage of 540 yuan. If the booked food cannot be delivered on time, the compensation fee for each week of delay per $ \ \mathrm{kg}$ is 0.5 yuan for food I and 0.6 yuan for food II. Under these conditions, how should the factory make comprehensive arrangements to minimize the total cost?

Table 1-11

Week	1	2	3	4	5	6	7	8
I	10000	10000	12000	12000	16000	16000	20000	20000
II	6000	7200	8400	10800	10800	12000	12000	12000

A fighter jet is a crucial combat tool, but to make a fighter jet effective, enough pilots are required. Therefore, a portion of the produced fighter jets, besides those used directly in combat, must be allocated for training pilots. Given that the annual production of fighter jets is $a_j(j=1, 2)$, with $a_1=10$ and $a_2=15$, furthermore, each fighter jet can train 5 pilots per year. How should the annual production of fighter jets be allocated to maximize their contribution to air defense over n years?

for a six-month period (January to June) to maximize its total net profit. The plan must detail monthly in-house production levels, outsourcing quantities, and workforce management (hiring/firing).

Initial Conditions (at the start of January):
- Initial Workforce: 1,000 employees
- Initial Inventory: 15,000 units

Revenue and Cost Structure:
- **Sales Price:** 300 Yuan per unit sold.
- **Raw Material Cost:** 90 Yuan per unit, applicable *only* to units produced in-house.
- **Outsourcing Cost:** 200 Yuan per unit for finished tables acquired from a third-party supplier. This is an all-inclusive cost.
- **Inventory Holding Cost:** 15 Yuan per unit for any inventory held at the end of a month.
- **Backorder Cost:** 35 Yuan per unit for any unfulfilled demand (stockout) carried over to the next month.

Labor and Production Parameters:
- **Labor Requirement:** Each in-house unit requires 5 labor hours to produce.
- **Regular Labor:** Each worker provides 160 regular working hours per month (8 hours/day * 20 days/month). The company pays a regular wage of 30 Yuan/hour for these 160 hours, regardless of full utilization.
- **Overtime Labor:** Workers can perform overtime. Total overtime hours per month for the entire workforce cannot exceed 20 hours per worker. The overtime wage is 40 Yuan/hour.
- **Workforce Management:** The company can hire or fire workers each month. The cost to hire a new worker is 5,000 Yuan, and the cost to fire a worker is 8,000 Yuan.

Demand and Fulfillment Logic:
- Unfulfilled demand from one month is back-ordered and must be met in subsequent months.

A farmer needs to decide how many cows, sheep, and chickens to raise in order to achieve maximum profit. The farmer can sell cows, sheep, and chickens for $500, $200, and $8 each, respectively. The feed costs for each cow, sheep, and chicken are $100, $80, and $5, respectively. The profit is the difference between the selling price and the feed cost. Each cow, sheep, and chicken produces 10, 5, and 3 units of manure per day, respectively. Due to the limited time the farm staff has for cleaning the farm each day, they can handle up to 800 units of manure. Additionally, because of the limited farm size, the farmer can raise at most 50 chickens. Furthermore, the farmer must have at least 10 cows to meet customer demand. The farmer must also raise at least 20 sheep. Finally, the total number of animals cannot exceed 100.

Mary is planning her dinner tonight. Every 100 grams of okra contains 3.2 grams of fiber, every 100 grams of carrots contains 2.7 grams of fiber, every 100 grams of celery contains 1.6 grams of fiber, and every 100 grams of cabbage contains 2 grams of fiber. How many grams of each type of food should Mary buy to maximize her fiber intake?

She is considering choosing one among salmon, beef, and pork as a protein source.

She also considers choosing at least two kinds of vegetables among okra, carrots, celery, and cabbage.

The price of salmon is $4 per 100 grams, beef is $3.6 per 100 grams, pork is $1.8 per 100 grams. The price of okra is $2.6 per 100 grams, carrots are $1.2 per 100 grams, celery is $1.6 per 100 grams, and cabbage is $2.3 per 100 grams. Mary has a budget of $15 for this meal.

The total food intake should be 600 grams.

The contract reservations for the next year for products I, II, and III of a certain factory in each quarter are shown in Table 1-10.

Table 1-10

Product	1	2	3	4
I	1500	1000	2000	1200
II	1500	1500	1200	1500
III	1000	2000	1500	2500

At the beginning of the first quarter, there is no inventory for these three products, and it is required to have 150 units in stock for each product by the end of the fourth quarter. It is known that the factory has 15,000 production hours per quarter, and each unit of products I, II, and III requires 2, 4, and 3 hours respectively. Due to a change in equipment, product I cannot be produced in the second quarter. It is stipulated that if the products cannot be delivered on time, a compensation of 20 yuan per unit per quarter delay is required for products I and II, while for product III, the compensation is 10 yuan. Additionally, for products produced but not delivered in the current quarter, the inventory cost is 5 yuan per unit per quarter. How should the factory schedule production to minimize the total cost of compensation and inventory?

in Verona, Perugia, Rome, Pescara, Taranto, and Lamezia) to major national ports (Genoa, Venice, Ancona, Naples, Bari). The container inventory at the warehouses is as follows:

	Empty Containers
Verona	10
Perugia	12
Rome	20
Pescara	24
Taranto	18
Lamezia	40

The demand at the ports is as follows:

	Container Demand
Genoa	20
Venice	15
Ancona	25
Naples	33
Bari	21

The transport is carried out by a fleet of trucks. The cost to transport each container is proportional to the distance traveled by the trucks, with a rate of 30 euros per kilometer. Each truck can carry up to 2 containers. The distances are as follows:

	Genoa	Venice	Ancona	Naples	Bari

Now, we need to determine 4 out of 5 workers to complete one of the four tasks respectively. Due to each worker's different technical specialties, the time required for them to complete each task varies. The hours required by each worker to complete each task are shown in Table 5-2.

Table 5-2

Worker	A	B	C	D
I	9	4	3	7
II	4	6	5	6
III	5	4	7	5
IV	7	5	2	3
V	10	6	7	4

Try to find a job assignment plan that minimizes the total working hours.

Haus Toys can manufacture and sell toy trucks, toy airplanes, toy boats, and toy trains. The profit for each truck sold is $5, each airplane $10, each boat $8, and each train $7. How many types of toys should Haus Toys manufacture to maximize profits?

There are 890 units of wood available. Each truck requires 12 units, each airplane 20 units, each boat 15 units, and each train 10 units.

There are 500 units of steel available. Each airplane requires 3 units, each boat 5 units, each train 4 units, and each truck 6 units.

If Haus Toys manufactures trucks, they will not manufacture trains.

However, if they manufacture boats, they will also manufacture airplanes.

The number of toy boats manufactured cannot exceed the number of toy trains manufactured.

A convenience supermarket is planning to open several chain stores in a newly built residential area in the northwest suburb of the city. For shopping convenience, the distance from any residential area to one of the chain stores should not exceed $800 \mathrm{~m}$. Table 5-1 shows the new residential areas and the residential areas within a radius of $800 \mathrm{~m}$ from each of them. Question: What is the minimum number of chain stores the supermarket needs to build among the mentioned residential areas, and in which residential areas should they be built?

Area Code	Residential Areas within $800 \mathrm{~m}$ Radius
A	A, C, E, G, H, I
B	B, H, I
C	A, C, G, H, I
D	D, J
E	A, E, G
F	F, J, K
G	A, C, E, G
H	A, B, C, H, I
I	A, B, C, H, I
J	D, F, J, K, L
K	F, J, K, L
L	J, K, L

A company produces two types of small motorcycles, where type A is entirely manufactured by the company, and type B is assembled from imported parts. The production, assembly, and inspection time required for each unit of these two products are shown in Table 3.2.

Table 3.2

Type	Process			Selling Price (Yuan/unit)
	Manufacturing	Assembly	Inspection	
Type A (hours/unit)	20	5	3	650
Type B (hours/unit)	0	7	6	725
Max production capacity per week (hours)	120	80	40	
Production cost per hour (Yuan)	12	8	10	

If the company's operational goals and targets are as follows:

p_{1} : The total profit per week should be at least 3000 yuan;

p_{2} : At least 5 units of type A motorcycles should be produced per week;

p_{3} : Minimize the idle time of each process as much as possible. The weight coefficients of the three processes are proportional to their hourly costs, and overtime is not allowed.

Try to establish a model for this problem.

Red Star Plastics Factory produces six distinct types of plastic containers. Each container type is characterized by a specific volume, market demand, and unit variable production cost, as detailed in Table 5-11.

Table 5-11: Container Data

Container Type (Code)	1	2	3	4	5	6
Volume (cm^3)	1500	2500	4000	6000	9000	12000
Market Demand (units)	500	550	700	900	400	300
Unit Variable Production Cost (Yuan/unit)	5	8	10	12	16	18

The production of any container type necessitates the use of its dedicated specialized equipment. If the decision is made to **activate** the production equipment for a particular container type (i.e., if the production quantity of that type is greater than zero), a fixed setup cost of 1200 Yuan is incurred for that specific equipment.

Should the production quantity of a certain container type be insufficient to meet its direct demand, the factory has the option to utilize other container types with **larger or equal volume** as substitutes to fulfill this unmet demand. For instance, type 2 containers (volume 2500 cm^3) can be used to satisfy the demand for type 1 containers (requiring a volume of 1500 cm^3), but type 1 containers cannot be used for type 2 demand. In this problem, the container type codes are pre-sorted in ascending order of their volumes.

Question:
How should the factory organize its production? The objective is to develop a production plan that minimizes the total costâ€”comprising the sum of variable production costs for all containers produced and the fixed costs for all activated equipmentâ€—while ensuring that the demand for all container types is fully met.

Tom and Jerry just bought a farm in Sunshine Valley, and they are considering using it to plant corn, wheat, soybeans, and sorghum. The profit per acre for planting corn is $1500, the profit per acre for planting wheat is $1200, the profit per acre for planting soybeans is $1800, and the profit per acre for planting sorghum is $1600. To maximize their profit, how many acres of land should they allocate to each crop? Tom and Jerryâ€™s farm has a total area of 100 acres.

The land area used for planting corn must be at least twice the land area used for planting wheat.

The land area used for planting soybeans must be at least half the land area used for planting sorghum.

The land area used for planting wheat must be three times the land area used for planting sorghum.

Mary is planning tonight's dinner. She wants to choose a combination of protein and vegetables to maximize her protein intake for the meal. Her protein options are chicken, salmon, and tofu, which can be bought in any quantity.

- Chicken: 23g protein, $3.00 cost, per 100g.
- Salmon: 20g protein, $5.00 cost, per 100g.
- Tofu: 8g protein, $1.50 cost, per 100g.

She also wants to choose from a list of five vegetables, sold in 100g packs. She must select at least three different types of vegetables.

- Broccoli (100g pack): 2.8g protein, $1.20 cost.
- Carrots (100g pack): 0.9g protein, $0.80 cost.
- Spinach (100g pack): 2.9g protein, $1.50 cost.
- Bell Pepper (100g pack): 1.0g protein, $1.00 cost.
- Mushrooms (100g pack): 3.1g protein, $2.00 cost.

Mary has two main constraints:
1. Her total budget is $20.
2. The total weight of all food must not exceed 800 grams.

How should Mary choose her ingredients to get the maximum possible amount of protein?

A certain factory needs to use a special tool over n planning stages. At stage j, r_j specialized tools are needed. At the end of this stage, all tools used within this stage must be sent for repair before they can be reused. There are two repair methods: one is slow repair, which is cheaper (costs b per tool) but takes longer (p stages to return); the other is fast repair, which costs c per tool $(c > b)$ and is faster, requiring only q stages to return $(q < p)$. If the repaired tools cannot meet the needs, new ones must be purchased, with a cost of a per new tool $(a > c)$. This special tool will no longer be used after n stages. Determine an optimal plan for purchasing and repairing the tools to minimize the cost spent on tools during the planning period.\n\nn = 10 # number of stages\nr = [3, 5, 2, 4, 6, 5, 4, 3, 2, 1] # tool requirements per stage, indexing starts at 1\na = 10 # cost of buying a new tool\nb = 1   # cost of slow repair\nc = 3   # cost of fast repair\np = 3   # slow repair duration\nq = 1   # fast repair duration

A store plans to formulate the purchasing and sales plan for a certain product for the first quarter of next year. It is known that the warehouse capacity of the store can store up to 500 units of the product, and there are 200 units in stock at the end of this year. The store purchases goods once at the beginning of each month. The purchasing and selling prices of the product in each month are shown in Table 1.3.

Table 1.3

Month	1	2	3
Purchasing Price (Yuan)	8	6	9
Selling Price (Yuan)	9	8	10

Now, determine how many units should be purchased and sold each month to maximize the total profit, and express this problem as a linear programming model.

Certain strategic bomber groups are tasked with destroying enemy military targets. It is known that the target has four key parts, and destroying at least two of them will suffice.

Resources and constraints:

Bomb stockpile: A maximum of 28 heavy bombs and 12 light bombs can be used.
Fuel limit: Total fuel consumption must not exceed 10,000 liters.
Fuel consumption rules: When carrying heavy bombs, each liter of fuel allows a distance of 2 km, whereas with light bombs, each liter allows 3 km. Additionally, each aircraft can only carry one bomb per trip, and each bombing run requires fuel not only for the round trip (each liter of fuel allows 4 km when the aircraft is empty) but also 100 liters for both takeoff and landing per trip.Â

Table 1-17

Key Part	Distance from Airport (km)	Probability of Destruction per Heavy Bomb	Probability of Destruction per Light Bomb
1	450	0.03	0.08
2	480	0.10	0.11
3	540	0.05	0.12
4	600	0.05	0.09

How should the bombing plan be determined to maximize the probability of success? What is the maximum probability of success?

A textile factory produces two types of fabrics: one for clothing and the other for curtains. The factory operates two shifts, with a weekly production time set at 110 hours. Both types of fabrics are produced at a rate of 1000 meters per hour. Assuming that up to 70,000 meters of curtain fabric can be sold per week, with a profit of 2.5 yuan per meter, and up to 45,000 meters of clothing fabric can be sold per week, with a profit of 1.5 yuan per meter, the factory has the following objectives in formulating its production plan:

p_{1} : The weekly production time must fully utilize 110 hours;

p_{2} : Overtime should not exceed 10 hours per week;

p_{3} : At least 70,000 meters of curtain fabric and 45,000 meters of clothing fabric must be sold per week;

p_{4} : Minimize overtime as much as possible.

Formulate a model for this problem.

A furniture store can choose to order chairs from three different manufacturers: A, B, and C. The cost of ordering each chair from manufacturer A is $50, from manufacturer B is $45, and from manufacturer C is $40. The store needs to minimize the total cost of the order.

Additionally, each order from manufacturer A will include 15 chairs, while each order from manufacturers B and C will include 10 chairs. The number of orders must be an integer. The store needs to order at least 100 chairs.

Each order from manufacturer A will include 15 chairs, while each order from manufacturers B and C will include 10 chairs. The store needs to order at most 500 chairs.

If the store decides to order chairs from manufacturer A, it must also order at least 10 chairs from manufacturer B.

Furthermore, if the store decides to order chairs from manufacturer B, it must also order chairs from manufacturer C.

Bright Future Toys wants to build and sell robots, model cars, building blocks, and dolls. The profit for each robot sold is $15, for each model car sold is $8, for each set of building blocks sold is $12, and for each doll sold is $5. How many types of toys should Bright Future Toys manufacture to maximize profit?
There are 1200 units of plastic available. Each robot requires 30 units of plastic, each model car requires 10 units of plastic, each set of building blocks requires 20 units of plastic, and each doll requires 15 units of plastic.

There are 800 units of electronic components available. Each robot requires 8 units of electronic components, each model car requires 5 units of electronic components, each set of building blocks requires 3 units of electronic components, and each doll requires 2 units of electronic components.

If Bright Future Toys manufactures robots, they will not manufacture dolls.

However, if they manufacture model cars, they will also manufacture building blocks.

The number of dolls manufactured cannot exceed the number of model cars manufactured.

A restaurant needs to order dining tables from three different suppliers, A, B, and C. The cost of ordering each dining table from Supplier A is $120, from Supplier B is $110, and from Supplier C is $100. The restaurant needs to minimize the total cost of the order.

Additionally, each order from Supplier A will include 20 tables, while each order from Suppliers B and C will include 15 tables. The number of orders must be an integer. The restaurant needs to order at least 150 tables.

Each order from Supplier A will include 20 tables, and each order from Suppliers B and C will include 15 tables. The restaurant needs to order no more than 600 tables.

If the restaurant decides to order tables from Supplier A, it must also order at least 30 tables from Supplier B.

Additionally, if the restaurant decides to order tables from Supplier B, it must also order tables from Supplier C.

month. The following table gives the maximum demand (unit $=100 \mathrm{~kg}$), price ($\$ / 100 \mathrm{Kg}$), production cost (per 100Kg product), and production quota (the maximum number of 100kg units that can be produced in one day if all production lines are devoted to this product).

Product	A_{1}	A_{2}	A_{3}
Maximum Demand	5300	4500	5400
Selling Price	124	109	115
Production Cost	73.30	52.90	65.40
Production Quota	500	450	550

The fixed activation cost of the production line is as follows:

Product	A_{1}	A_{2}	A_{3}
Activation Cost	170000	150000	100000

Minimum production batch:

$$
\begin{array}{c|ccc}
Product & A_{1} & A_{2} & A_{3} \\
\hline
Minimum Batch & 20 & 20 & 16
\end{array}
$$

Please formulate an operations research model to determine a production plan that maximizes total

Hongdou Clothing Factory uses three special equipment to produce shirts, short-sleeved shirts, and casual clothes respectively. It is known that the labor, material usage, selling price, and variable cost of each of the above products are as shown in Table 5-10.

Table 5-10

Product Name	Labor per unit	Material per unit	Selling Price	Variable Cost
Shirt	3	4	120	60
Short-sleeve	2	3	80	40
Casual Cloth	6	6	180	80

It is known that the available labor per week is 1500 units, the available material is 1600 units, and the weekly fixed costs for the three special equipment for producing shirts, short-sleeved shirts, and casual clothes are 2000, 1500, and 1000 respectively. Design a weekly production plan for the factory to maximize its profit.

A manufacturing company needs to transport 1800 units of product from the warehouse to three different sales points. The company has four transportation options to choose from: truck, van, motorcycle, and electric vehicle. Since the van and electric vehicle both consume a lot of energy, the company wants to choose only one of these two options. Each trip with a truck generates 100 units of pollution, a van generates 50 units of pollution, a motorcycle generates 10 units of pollution, and an electric vehicle generates 0 units of pollution. The total pollution generated from all trips cannot exceed 2000 units. At least 10 trips must use a truck. Trucks, vans, motorcycles, and electric vehicles can transport 100 units, 80 units, 40 units, and 60 units of product per trip, respectively. The company needs to ensure that the total amount of transported product is at least 1800 units.

An investor plans to invest 100,000 yuan, with two investment options to choose from. The first investment guarantees a return of 0.7 yuan for every 1 yuan invested after one year. The second investment guarantees a return of 2 yuan for every 1 yuan invested after two years, but the investment time must be in multiples of two years. In order to maximize the investor's earnings by the end of the third year, how should the investments be made? Formulate this as a linear programming problem.

The number of salespeople required at a 24-hour convenience store in different time periods is as follows: 2:00-6:00 - 10 people, 6:00-10:00 - 15 people, 10:00-14:00 - 25 people, 14:00-18:00 - 20 people, 18:00-22:00 - 18 people, 22:00-2:00 - 12 people. Salespeople start their shifts at 2:00, 6:00, 10:00, 14:00, 18:00, and 22:00, working continuously for 8 hours. Determine the minimum number of salespeople needed to meet the requirements.

A factory produces three types of products: I, II, and III. Each product needs to go through two processing procedures, A and B. The factory has two pieces of equipment that can complete process A, denoted as A1 and A2; it has three pieces of equipment that complete process B, denoted as B1, B2, and B3. Product I can be processed on any equipment for A and B; Product II can be processed on any A equipment but only on B1 for process B; Product III can only be processed on A2 and B2. Given the unit processing time on various machines, raw material costs, product sale prices, effective machine hours, and the costs of operating the machines at full capacity as shown in Table 1-4, the task is to arrange the optimal production plan to maximize the factory's profit.

Table 1-4

Equipment	Product I	Product II	Product III	Effective Machine Hours	Operating Costs at Full Capacity (Yuan)
A1	5	10		6000	300
A2	7	9	12	10000	321
B1	6	8		4000	250
B2	4		11	7000	783
B3	7			4000	200
Raw Material Cost (Yuan/Unit)	0.25	0.35	0.50		
Unit Price (Yuan/Unit)	1.25	2.00	2.80		

Someone has a fund of 300,000 yuan and has the following investment projects in the next three years:
(1) Investment can be made at the beginning of each year within three years, with an annual profit of 20% of the investment amount, and the principal and interest can be used for investment in the following year;
(2) Investment is only allowed at the beginning of the first year, and it can be recovered at the end of the second year, with the total principal and interest amounting to 150% of the investment amount, but the investment limit is no more than 150,000 yuan;
(3) Investment is allowed at the beginning of the second year within three years, and it can be recovered at the end of the third year, with the total principal and interest amounting to 160% of the investment amount, and the investment limit is 200,000 yuan;
(4) Investment is allowed at the beginning of the third year within three years, and it can be recovered in one year with a profit of 40%, and the investment limit is 100,000 yuan.
Chapter One: Linear Programming and Simplex Method
Try to determine an investment plan for this person that maximizes the principal and interest at the end of the third year.

Donghai City and Nanjiang City. The demand for different professionals in these regional branches is shown in Table 4-3. After assessing the situation of the applicants, the company has categorized them into 6 types. Table 4-4 lists the specialties each type of person can handle, the specialty they prefer, and the city they prefer to work in. The company's personnel arrangement considers the following three priorities:
p_1: All three types of professionals needed are fully met;
p_2: 8000 recruited personnel meet their preferred specialty;
p_3: 8000 recruited personnel meet their preferred city.
Try to establish a mathematical model for goal planning accordingly.

Table 4-3

Branch Location	Specialty	Demand
Donghai City	1	1000
Donghai City	2	2000
Nanjiang City	3	1500
Nanjiang City	1	2000
Nanjiang City	2	1000
Nanjiang City	3	1000

Table 4-4

Type	Number of People	Suitable Specialty	Preferred Specialty	Preferred City
1	1500	1,2	1	Donghai
2	1500	2,3	2	Donghai
3	1500	1,3	1	Nanjiang
4	1500	1,3	3	Nanjiang
5	1500	2,3	3	Donghai

Suppose a certain animal needs at least $700 \mathrm{~g}$ of protein, $30 \mathrm{~g}$ of minerals, and $100 \mathrm{mg}$ of vitamins daily. There are 5 types of feed available, and the nutritional content and price per gram of each type of feed are shown in Table 1-5:

Try to formulate a linear programming model that meets the animal's growth needs while minimizing the cost of selecting the feed.

Table 1-6

Feed	Protein (g)	Minerals (g)	Vitamins (mg)	Price (Â¥/kg)	Feed	Protein (g)	Minerals (g)	Vitamins (mg)	Price (Â¥/kg)
1	3	1	0.5	0.2	4	6	2	2	0.3
2	2	0.5	1	0.7	5	18	0.5	0.8	0.8
3	1	0.2	0.2	0.4					

A factory produces three types of products: I, II, and III. Each product must undergo two processing stages, A and B. The factory has two types of equipment to complete stage A (A1, A2) and three types of equipment to complete stage B (B1, B2, B3).

The production rules are as follows:
- Product I can be processed on any type of A equipment (A1 or A2) and any type of B equipment (B1, B2, or B3).
- Product II can be processed on any type of A equipment (A1 or A2), but for stage B, it can only be processed on B1 equipment.
- Product III can only be processed on A2 equipment for stage A and B2 equipment for stage B.

The detailed data for processing time per piece, costs, sales price, and machine availability is provided in the table below. The objective is to determine the optimal production plan to maximize the factory's total profit.

Data Table

Equipment	Product I	Product II	Product III	Effective Machine Hours	Processing Cost per Machine Hour (Yuan/hour)
A1	5	10	-	6000	0.05
A2	7	9	12	10000	0.03
B1	6	8	-	4000	0.06
B2	4	-	11	7000	0.11
B3	7	-	-	4000	0.05
Raw Material Cost (Yuan/piece)	0.25	0.35	0.5	-	-
Unit Price (Yuan/piece)	1.25	2	2.8	-	-

A product consists of three components produced by four workshops, each with a limited number of production hours. Table 1.4 below provides the production rates of the three components. The objective is to determine the number of hours each workshop should allocate to each component to maximize the number of completed products. Formulate this problem as a linear programming problem.

Table 1.4

Workshop	Production Capacity (hours)	Production Rate (units/hour)		
		Component 1	Component 2	Component 3
A	100	10	15	5
B	150	15	10	5
C	80	20	5	10
D	200	10	15	20

A wealthy noble passed away, leaving the following inheritance:

- A painting by Caillebotte: $25000
- A bust of Diocletian: $5000
- A Yuan dynasty Chinese vase: $20000
- A 911 Porsche: $40000
- Three diamonds: each $12000
- A Louis XV sofa: $3000
- Two very precious Jack Russell racing dogs: each $3000 (will stipulates they must not be separated)
- A sculpture from 200 AD: $10000
- A sailing boat: $15000
- A Harley Davidson motorcycle: $10000
- A piece of furniture once belonging to Cavour: $13000,

which must be shared between two sons. How to formulate a mathematical program and solve it using COPTPY to minimize the difference in value between the two parts?

The current problem faced by the company is how to use the fewest number of containers to pack the currently needed goods for transportation, while considering the weight of the goods, specific packaging requirements, and inventory limitations. Professional modeling and analysis are needed for a batch of goodsâ€™ transportation strategy to ensure maximum utilization of the limited container space.

The company currently has a batch to be transported, with each container able to hold a maximum of 60 tons of goods and each container used must load at least 18 tons of goods. The goods to be loaded include five types: A, B, C, D, and E, with quantities of 120, 90, 300, 90, and 120 respectively. The weights are 0.5 tons for A, 1 ton for B, 0.4 tons for C, 0.6 tons for D, and 0.65 tons for E. Additionally, to meet specific usage requirements, every time A goods are loaded, at least 1 unit of C must also be loaded, but loading C alone does not require simultaneously loading A; and considering the demand limitation for D goods, each container must load at least 12 units of D.

Establish an operations research model so that the company can use the fewest number of containers to pack this batch of goods.

A fabric dyeing plant has 3 dyeing vats. Each batch of fabric must be dyed in sequence in each vat: first, the second, and third vats. The plant must color five batches of fabric of different sizes. The time required in hours to dye batch i in vat j is given in the following matrix:

$$
\left(\begin{array}{ccc}
3 & 1 & 1 \\
2 & 1.5 & 1 \\
3 & 1.2 & 1.3 \\
2 & 2 & 2 \\
2.1 & 2 & 3
\end{array}\right)
$$

Schedule the dyeing operations in the vats to minimize the completion time of the last batch.

combinatorial optimization problem. The basic VRP can be described as follows: in a certain area, there is a number of customers and a distribution center or depot. Customers are generally located at different positions, and each has a specific demand for goods. The distribution center needs to dispatch a fleet of vehicles and design appropriate delivery routes to fulfill the demands of all customers. The objective of VRP is to optimize a certain benefit metric while satisfying all customer demands. The benefit metric is usually presented as an objective function, which varies according to the company's requirements. Common objective functions include minimizing the total distance traveled by vehicles, minimizing the total delivery time, or minimizing the number of vehicles used. In addition to satisfying customer demands, VRP often needs to consider various other constraints, leading to several variants. For example, if the vehicle's load cannot exceed its maximum capacity, the problem becomes the Capacitated Vehicle Routing Problem (CVRP). If each customer's delivery must be made within a specific time frame, the problem becomes the Vehicle Routing Problem with Time Windows (VRPTW).

The Vehicle Routing Problem with Time Windows (VRPTW) is a classic variant of the VRP. There are many real-world applications of VRPTW, as customer locations often have service time windows. For instance, some logistics centers need to stock parcels during off-peak hours, and large supermarkets need to replenish goods outside of business hours. Real-time delivery services like food delivery also require strict delivery time windows. Time windows can be categorized as hard or soft. A Hard Time Window (HTW) means that a vehicle must arrive at the delivery point within or before the time window; late arrivals are not permitted. If a vehicle arrives early, it must wait until the time window opens to begin service. This is common in scenarios like supermarket restocking and logistics center inbound operations. A Soft Time Window (STW) means that a vehicle is not strictly required to arrive within the time window, but it is encouraged to do so. A penalty is incurred for early or late arrivals. This is applicable in scenarios such as meal delivery, school bus services, and industrial deliveries.

The Vehicle Routing Problem with Hard Time Windows (VRPHTW) can be described as follows: within a region, there is a set of customer locations and a central depot. Vehicles must start from the depot and return to the depot, following continuous paths. Each customer must be served by exactly one vehicle, and

A factory produces two types of microcomputers, A and B. Each type of microcomputer requires the same two production processes. The processing time, profit from sales, and the maximum weekly processing capacity for each type are shown in Table 3.1.

Table 3.1

Process	Model		Maximum Weekly Processing Capacity
	A	B	
I (hours / unit)	4	6	150
II (hours / unit)	3	2	70
Profit ($ per unit)	300	450	

The expected values for the factory's operational goals are as follows:

p_{1}: The total weekly profit must not be less than $10,000.

p_{2}: Due to contractual requirements, at least 10 units of Model A and at least 15 units of Model B must be produced per week.

p_{3}: The weekly production time for Process I should be exactly 150 hours, and the production time for Process II should be fully utilized, with potential overtime if necessary.

Try to establish the mathematical programming model for this problem.

There are three different products to be processed on three machine tools. Each product must first be processed on machine 1, then sequentially on machines 2 and 3. The order of processing the three products on each machine should remain the same. Assuming t_{ij} represents the time to process the i-th product on the j-th machine, how should the schedule be arranged to minimize the total processing cycle for the three products? The timetable is as follows:

Product	Machine 1	Machine 2	Machine 3
Product 1	2	3	1
Product 2	4	2	3
Product 3	3	5	2

A company plans to transport goods between the city and the suburb and needs to choose the most environmentally friendly transportation method. The company can choose from the following three methods: motorcycle, small truck, and large truck. Each motorcycle trip produces 40 units of pollution, each small truck trip produces 70 units of pollution, and each large truck trip produces 100 units of pollution. The company's goal is to minimize total pollution.

The company can only choose two out of these three transportation methods.

Due to certain road restrictions, the number of motorcycle trips cannot exceed 8.

Each motorcycle trip can transport 10 units of products, each small truck trip can transport 20 units of products, and each large truck trip can transport 50 units of products. The company needs to transport at least 300 units of products.

The total number of trips must be less than or equal to 20.

The independent country of Carelland mainly exports four commodities: steel, engines, electronic components, and plastic. Carelland's Minister of Finance (i.e., Minister of Economy) wants to maximize exports and minimize imports. The unit prices of steel, engines, electronics, and plastic on the world market are, in local currency (Klunz), 500, 1500, 300, 1200 respectively. Producing 1 unit of steel requires 0.02 units of engines, 0.01 units of plastic, 250 Klunz of other imported goods, and 6 person-months of labor. Producing 1 unit of engines requires 0.8 units of steel, 0.15 units of electronic components, 0.11 units of plastic, 300 Klunz of imported goods, and 1 person-year. One unit of electronics requires: 0.01 units of steel, 0.01 units of engines, 0.05 units of plastic, 50 Klunz of imported goods, and 6 person-months of labor. One unit of plastic requires: 0.03 units of engines, 0.2 units of steel, 0.05 units of electronic components, 300 Klunz of imported goods, and 2 person-years. Engine production is limited to 650000 units, and plastic production is limited to 60000 units. The total available labor force per year is 830000 person-months. Write a mathematical program to maximize domestic GDP and solve the problem using AMPL.

A person has a fund of 500,000 yuan and the following investment projects available in the next three years:

(1) Investment can be made at the beginning of each year within three years, and the annual profit is 20% of the investment amount.

(2) Investment is only allowed at the beginning of the first year, and can be recovered at the end of the second year, with the total principal and interest being 150% of the investment amount. However, this type of investment is limited to no more than 120,000 yuan.

(3) Investment at the beginning of the second year, recoverable at the end of the second year, with the total principal and interest being 160% of the investment amount. This type of investment is limited to 150,000 yuan.

(4) Investment is allowed at the beginning of the third year, recoverable in one year, with a profit of 40%, and the investment limit is 100,000 yuan.

Determine an investment plan for the person that maximizes the total principal and interest by the end of the third year.

Two steel furnaces at a steel plant each use two methods of steelmaking simultaneously. The first method takes $a=2$ hours per furnace and costs $m=50$ in fuel expenses; the second method takes $b=3$ hours per furnace and costs $n=70$ in fuel expenses. Assuming each furnace produces $k=10$ tons of steel regardless of the method used, and that at least $d=30$ tons of steel must be produced within $c=12$ hours, how should these two methods be allocated to minimize fuel expenses? Formulate this problem as a linear programming model.

A production base needs to extract raw materials from warehouses A and B every day for production. The required raw materials are: at least 240 pieces of raw material A, at least 80 kg of raw material B, and at least 120 tons of raw material C. It is known that: Each truck from warehouse A can transport back to the production base 4 pieces of raw material A, 2 kg of raw material B, 6 tons of raw material C, with a freight cost of 200 yuan per truck; each truck from warehouse B can transport back to the production base 7 pieces of raw material A, 2 kg of raw material B, 2 tons of raw material C per day, with a freight cost of 160 yuan per truck. Question: In order to meet production needs, how many trucks should be dispatched daily from warehouse A and warehouse B to minimize the total freight cost?

Given that there are $m=2$ production points for a certain type of material, where the output at the i-th point $(i=1,2)$ is a_i, $a_1 = 100$, and $a_2 = 150$. This material is to be shipped to $n=2$ demand points, where the demand at the j-th point $(j=1, 2)$ is b_j, $b_1 = 80$, and $b_2 = 120$. It is known that $\sum_i a_i \geqslant \sum_j b_j$. It is also known that when shipping from production points to demand points, it must pass through one of the $p=2$ intermediate marshaling stations. If the k-th $(k=1, 2)$ intermediate marshaling station is used, a fixed cost f_k is incurred regardless of the transshipment volume, where $f_1 = 10$ and $f_2 = 15$. The k-th intermediate marshaling station has a maximum transshipment capacity limitation q_k, where $q_1 = 100$ and $q_2 = 100$. Let $c_{i k}$ and $c'_{k j}$ denote the unit transportation cost from i to k and from k to j, respectively, where $c_{11}=2$, $c_{12}=3$, $c_{21}=4$, $c_{22}=1$, $c'_{11}=3$, $c'_{12}=2$, $c'_{21}=1$, and $c'_{22}=4$. Try to determine a transportation plan for this material that minimizes the total cost.

A factory produces three types of products, A, B, and C. Each unit of product A requires 1 hour for technical preparation, 10 hours of direct labor, and 3 kg of materials. Each unit of product B requires 2 hours for technical preparation, 4 hours of labor, and 2 kg of materials. Each unit of product C requires 1 hour for technical preparation, 5 hours of labor, and 1 kg of materials. The available technical preparation time is 100 hours, labor time is 700 hours, and materials are 400 kg. The company offers larger discounts for bulk purchases, as detailed in Table 1-22. Determine the company's production plan to maximize profit.

Table 1-22

Product A		Product B		Product C	
Sales Volume (pieces)	Profit (yuan)	Sales Volume (pieces)	Profit (yuan)	Sales Volume (pieces)	Profit (yuan)
0 ~ 40	10	0 ~ 50	6	0 ~ 100	5
40 ~ 100	9	50 ~ 100	4	Above 100	4
100 ~ 150	8	Above 100	3		
Above 150	7				

A university computer lab hires 4 undergraduates (designated 1, 2, 3, and 4) and 2 graduate students (designated 5 and 6) for duty answering questions. The maximum duty hours from Monday to Friday and the hourly wage for each person are shown in Table 5-9.

Table 5-9

Student ID	Wage (CNY/h)	Monday	Tuesday	Wednesday	Thursday	Friday
1	10.0	6	0	6	0	7
2	10.0	0	6	0	6	0
3	9.9	4	8	3	0	5
4	9.8	5	5	6	0	4
5	10.8	3	0	4	8	0
6	11.3	0	6	0	6	3

The lab operates from 8:00 AM to 10:00 PM, and there must be one and only one student on duty during open hours. It is also required that each undergraduate must work at least 8 hours per week, and each graduate student must work at least 7 hours per week. Additionally, supplement the following requirements: each student can work no more than 2 shifts per week, and no more than 3 students can be scheduled for duty each day. Based on these conditions, establish a new mathematical model.

A certain farm has 100 hectares of land and 15,000 yuan in funds for production development. The labor force situation on the farm is 3,500 person-days in autumn and winter, and 4,000 person-days in spring and summer. If the labor force itself is not fully utilized, they can work externally, earning 2.1 yuan/person-day in spring and summer and 1.8 yuan/person-day in autumn and winter.

The farm cultivates three types of crops: soybeans, corn, and wheat, and also raises dairy cows and chickens. Crop cultivation requires no specialized investment, but raising animals involves an investment of 400 yuan per dairy cow and 3 yuan per chicken. Raising dairy cows requires allocating 1.5 hectares of land per cow to grow feed, and involves 100 person-days in autumn and winter, and 50 person-days in spring and summer per cow. The annual net income is 400 yuan per dairy cow. Raising chickens does not use land, requires 0.6 person-days in autumn and winter, and 0.3 person-days in spring and summer per chicken. Annual net income is 2 yuan per chicken. The current chicken coop can accommodate up to 3,000 chickens, and the cow barn can accommodate up to 32 dairy cows. The labor and income requirements for the three types of crops per year are shown in Table 1-9.

Table 1-9

Item	Soybean	Corn	Wheat
Person-days (Autumn/Winter)	20	35	10
Person-days (Spring/Summer)	50	75	40
Annual Net Income (Yuan/hectare)	175	300	120

Determine the farm's operating plan to maximize annual net income. Please note that Labor days are calculated in whole days, fractions are not allowed.

A factory produces two models of microcomputers, A and B. Each model requires the same two processes. The processing time, sales profit, and the factoryâ€™s maximum weekly processing capacity for each model are shown in Table 3.1.

Table 3.1

Process	Model		Maximum Weekly Processing Capacity
	A	B	
I (hours/unit)	4	6	150
II (hours/unit)	3	2	70
Profit (yuan/unit)	300	450	

Given the factory's business goals:

p_{1}: The total weekly profit should not be less than 10,000 yuan;

p_{2}: Due to contract requirements, at least 10 units of model A and at least 15 units of model B must be produced each week;

p_{3}: The processing time for Process I should be exactly 150 hours per week, and the processing time for Process II should ideally be fully utilized, with potential for appropriate overtime;

p_{4}: If products are produced during overtime in Process II, the profit per unit is reduced by 20 yuan for model A and 25 yuan for model B, and the maximum overtime for Process II is 30 hours per week. Formulate the mathematical model for this problem.

A factory needs to rent a warehouse to store materials in the next 4 months. The required warehouse area for each month is listed in Table 1-14.

Table 1-14

Month	1	2	3	4
Required warehouse area (ãŽ¡)	1500	1000	2000	1200

The longer the rental contract period, the greater the discount on warehouse rental fees. The specific data is listed in Table 1-15.

Table 1-15

Contract rental period (months)	1	2	3	4
Rental fees for warehouse area during the contract period (yuan)				

A store has formulated a purchase and sales plan for a certain product from July to December. It is known that the warehouse capacity must not exceed 500 units, with 200 units in stock at the end of June. Thereafter, purchases are made at the beginning of each month. Assume the purchase and selling prices of this product for each month are shown in Table 1-21. How much should be purchased and sold each month to maximize the total revenue?

Table 1-21

Month	7	8	9	10	11	12
Buy	28	24	25	27	23	23
Sell	29	24	26	28	22	25

The number of nurses required in each time period over 24 hours at a certain hospital is as follows: 2:00-6:00 - 10 people, 6:00-10:00 - 15 people, 10:00-14:00 - 25 people, 14:00-18:00 - 20 people, 18:00-22:00 - 18 people, 22:00-2:00 - 12 people. Nurses start shifts in 6 batches at 2:00, 6:00, 10:00, 14:00, 18:00, and 22:00 and work continuously for 8 hours. Please determine: If the hospital can hire contract nurses with the same working hours as regular nurses, and if the pay for regular nurses is 10 yuan/hour and for contract nurses is 15 yuan/hour, should the hospital hire contract nurses and if so, how many?

For a certain 24-hour bus service, the number of drivers and crew members required during different time periods each day is shown in Table 1-2:

Table 1-2

Shift	Time	Required number	Shift	Time	Required number
1	$6: 00 \sim 10: 00$	60	4	$18 ; 00 \sim 22 ; 00$	50
2	$10 ; 00 \sim 14 ; 00$	70	5	$22 ; 00 \sim 2 ; 00$	20
3	$14 ; 00 \sim 18 ; 00$	60	6	$2: 00 \sim 6 ; 00$	30

Assuming that drivers and crew members start their shifts at the beginning of each time period and work continuously for 8 hours, determine the minimum number of drivers and crew members needed for this bus route. Formulate the linear programming model for this problem.

The Zhang family has 6 children: Harry, Hermione, Ron, Fred, George, and Ginny. The cost of taking Harry is $1200, Hermione is $1650, Ron is $750, Fred is $800, George is $800, and Ginny is $1500. Which children should the couple take to minimize the total cost of taking the children? They can take up to four children on the upcoming trip.

Ginny is the youngest, so the Zhang family will definitely take her.

If the couple takes Harry, they will not take Fred because Harry does not get along with him.

If the couple takes Harry, they will not take George because Harry does not get along with him.

If they take George, they must also take Fred.

If they take George, they must also take Hermione.

Even though it will cost them a lot of money, the Zhang family has decided to take at least three children.

Given that a certain factory plans to produce three types of products, I, II, and III, each product needs to be processed on equipment A, B, C as shown in Table 2-3:

Table 2-3

Equipment Code	I	II	III	Effective Monthly Equipment Hours
A	8	2	10	300
B	10	5	8	400
C	2	13	10	420
Unit Product Profit (per thousand yuan)	3	2	2.9	

How can the equipment capacity be fully utilized to maximize production profit?

A master's student in Operations Research at a certain university is required to select two courses in mathematics, two in operations research, and two in computer science from a total of seven courses: Calculus, Operations Research, Data Structures, Management Statistics, Computer Simulation, Computer Programming, and Forecasting. Some courses belong to only one category: Calculus falls under Mathematics, Computer Programming under Computer Science. However, some courses fall under multiple categories: Operations Research can be considered both Operations Research and Mathematics, Data Structures both Computer Science and Mathematics, Management Statistics both Mathematics and Operations Research, Computer Simulation both Computer Science and Operations Research, and Forecasting both Operations Research and Mathematics. Courses that fall under multiple categories can fulfill the requirement of both categories simultaneously. Additionally, some courses have prerequisites: Computer Simulation or Data Structures requires Computer Programming first, Management Statistics requires Calculus first, and Forecasting requires Management Statistics first. The question is: What is the minimum number of courses a master's student must take, and which specific courses, to meet the above requirements?

A trading company specializes in the wholesale business of certain grains. The company currently has a warehouse with a capacity of 5000 dan. On January 1, the company has 1000 dan of grain in stock and 20,000 yuan in funds. The estimated grain prices for the first quarter are shown in Table 1-8.

Table 1-8

Month	Purchase Price (yuan/dan)	Selling Price (yuan/dan)
1	2.85	3.10
2	3.05	3.25
3	2.90	2.95

The purchased grains will be delivered in the same month but can only be sold in the next month, and payment is required upon delivery. The company hopes to have an inventory of 2000 dan at the end of the quarter. What purchasing and selling strategy should be adopted to maximize the total profit over the three months?

Assuming a paper mill receives three orders for rolls of paper, with length and width requirements as shown in Table 1.2.

Table 1.2

Order Number	Width (meters)	Length (meters)
1	0.5	1000
2	0.7	3000
3	0.9	2000

The mill produces rolls of paper with standard widths of 1 meter and 2 meters. Assuming the length of the rolls is unlimited and can be spliced to reach the required length, how should the rolls be cut to minimize the area of waste?

Vicky and David have just bought a farm in the Yarra Valley, and they are considering using it to grow apples, pears, oranges, and lemons. The profit for growing one acre of apples is $2000, for one acre of pears is $1800, for one acre of oranges is $2200, and for one acre of lemons is $3000. To achieve maximum profit, how many acres of land should they use to grow each type of fruit? Vicky and David have just bought a farm in the Yarra Valley with a total area of 120 acres.

The land used to grow apples should be at least twice the land used to grow pears.

The land used to grow apples should be at least three times the land used to grow lemons.

The land used to grow oranges must be twice the land used to grow lemons.

Vicky and David are unwilling to grow more than two types of fruit.

A candy factory uses raw materials A, B, and C to process three different brands of candies, A, B, and C. It is known that the content of A, B, and C in each brand of candy, the cost of raw materials, the monthly limit of each raw material, and the unit processing fee and selling price of the three brands of candies are shown in Table 1-7.

Table 1-7

Item	A	B	C	Raw Material Cost (Yuan/kg)	Monthly Limit (kg)
A	â‰¥ 60%	â‰¥ 15%		2.00	2000
B				1.50	2500
C	â‰¤ 20%	â‰¤ 60%	â‰¤ 50%	1.00	1200
Processing Fee (Yuan/kg)	0.50	0.40	0.30		
Selling Price (Yuan/kg)	3.40	2.85	2.25		

How many kilograms of each of the three brands of candies should the factory produce each month to maximize the profit?

A traveling salesman must visit 7 customers at 7 different locations, with the (symmetric) distance matrix as follows:

	1	2	3	4	5	6	7
1	-	86	49	57	31	69	50
2		-	68	79	93	24	5
3			-	16	7	72	67
4				-	90	69	1
5					-	86	59
6						-	81

Formulate a mathematical program to determine the visiting order starting and ending at location 1 to minimize the travel distance, and solve it using COPTPY.

A product can be processed on any one of the four devices: A, B, C, or D. The preparation completion costs when each device is enabled, the unit production cost for the product, and the maximum processing capacity of each device are shown in Table 5-7. If 2000 units of the product need to be produced, how can the total cost be minimized? Try to establish a mathematical model.

Table 5-7

Device	Prep Completion Cost (Yuan)	Unit Production Cost (Yuan/Unit)	Maximum Processing Capacity (Units)
A	1000	20	900
B	920	24	1000
C	800	16	1200
D	700	28	1600

The Zhang family is deciding to invest in several different restaurants. The annual revenue of Restaurant A is $15,000, Restaurant B is $40,000, Restaurant C is $30,000, and Restaurant D is $50,000. They need to decide whether to purchase each restaurant, with each restaurant being able to be purchased only once. Help them decide which restaurants to buy to maximize their annual income.
The cost of Restaurant A is 1.6 million, Restaurant B is 2.5 million, Restaurant C is 1.8 million, and Restaurant D is 3 million. The Zhang family's investment budget is 6 million.

If they purchase Restaurant D, then they cannot purchase Restaurant A.

A farmer needs to transport 1000 units of fresh produce from the farm to a nearby market. The farmer has three transportation options: a horse, a bicycle, and a handcart. Since both the bicycle and handcart are very physically demanding, the farmer wants to choose only one of these two transportation methods. The horse generates 80 units of pollution per trip, the bicycle generates 0 units of pollution, and the handcart generates 0 units of pollution. The total amount of pollution generated by all trips must not exceed 1000 units. At least 8 trips must be made using the horse. The horse, bicycle, and handcart can carry 55 units, 30 units, and 40 units of produce per trip respectively. The farmer needs to ensure that the total amount of transported produce is at least 1000 units.

A company needs to decide whether to hire some of the five candidates to join their R&D team. The salary requirements for candidates F, G, H, I, and J are $12,000, $15,000, $18,000, $5,000, and $10,000 respectively. The company wants to minimize the total amount paid to candidates without exceeding the budget.

The company's budget is $40,000 and they wish to hire a maximum of 4 new employees.

The skill levels of the candidates are as follows:
Candidate F: Level 2
Candidate G: Level 3
Candidate H: Level 4
Candidate I: Level 1
Candidate J: Level 2

The company needs to ensure that the total skill level of the hired employees is at least 8.

The project management experience years of each candidate are as follows:
Candidate F: 1 year
Candidate G: 2 years
Candidate H: 2 years
Candidate I: 5 years
Candidate J: 4 years

They hope the total project management experience of the team is at least 8 years.

Due to the similar technical background of candidates G and J, the company can choose at most one of them.

A company produces two types of products: microwave ovens and water heaters, which are manufactured in both workshops A and B. It is known that apart from the purchased parts, the production of one microwave oven requires 2 hours of processing in workshop A and 1 hour of assembly in workshop B. The production of one water heater requires 1 hour of processing in workshop A and 3 hours of assembly in workshop B. After production, both products need inspection, sales, and other procedures. The inspection and sales cost for each microwave oven is 30 yuan, and for each water heater is 50 yuan. Workshop A has 250 hours of available production time per month, with each hour costing 80 yuan; workshop B has 150 hours of available production time per month, with each hour costing 20 yuan. It is estimated that an average of 80 microwave ovens and 50 water heaters can be sold per month next year. Based on these actual conditions, the company has established the following monthly plan constraints:

1. Inspection and sales costs should not exceed 5500 yuan per month;
2. At least 80 microwave ovens should be sold per month;
3. The production hours of both workshops A and B should be fully utilized;
4. Overtime in workshop A should not exceed 20 hours;
5. At least 50 water heaters should be sold per month.

Try to determine the monthly production plan for the company.

A toy company manufactures three types of tabletop golf toys, each requiring different manufacturing techniques. The high-end type requires 17 hours of manufacturing labor, 8 hours of inspection, and yields a profit of 300 yuan per unit. The mid-range type requires 10 hours of labor, 4 hours of inspection, and yields a profit of 200 yuan per unit. The low-end type requires 2 hours of labor, 2 hours of inspection, and yields a profit of 100 yuan per unit. Available labor hours are 1000, and available inspection hours are 500. Additionally, market forecasts indicate a demand of no more than 50 units for the high-end type, no more than 80 units for the mid-range type, and no more than 150 units for the low-end type. Determine the production plan for the company to maximize profit.

The market demand for products I and II is as follows: Product I requires 10,000 units per month from January to April, 30,000 units per month from May to September, and 100,000 units per month from October to December. Product II requires 15,000 units per month from March to September and 50,000 units per month during other months. The cost of producing these two products at a certain factory is as follows: Product I costs 5 yuan per unit to produce from January to May, and 4.50 yuan per unit from June to December; Product II costs 8 yuan per unit to produce from January to May, and 7 yuan per unit from June to December. The factory's combined production capacity for both products should not exceed 120,000 units per month. Product I has a volume of 0.2 cubic meters per unit, Product II has a volume of 0.4 cubic meters per unit, and the factory's warehouse capacity is 15,000 cubic meters. If the factory's warehouse space is insufficient, external warehouse space can be rented. Using the factoryâ€™s own warehouse costs 1 yuan per cubic meter per month, while renting an external warehouse increases this cost to 1.5 yuan per cubic meter per month. Given that the initial inventory of both products at the beginning of July is zero, how should production be scheduled from July to December to minimize the total production and inventory costs while meeting market demand?

There are two coal yards A and B, each receiving no less than 80 tons and 100 tons of coal per month, respectively. They are responsible for supplying coal to three residential areas, which need 55 tons, 75 tons, and 50 tons of coal per month, respectively. Coal yard A is located 10 kilometers, 5 kilometers, and 6 kilometers from these three residential areas. Coal yard B is located 4 kilometers, 8 kilometers, and 15 kilometers from these three residential areas. How should these two coal yards distribute coal to the three residential areas to minimize the ton-kilometers of transportation?

A steel reinforcement workshop produces a batch of steel bars (with the same diameter), consisting of 90 pieces of 3 meters in length and 60 pieces of 4 meters in length. It is known that each piece of raw steel bar used is 10 meters in length. How can the raw material be cut most efficiently? Establish a linear programming model for this problem.

The famous Traveling Salesman Problem (TSP) in operations research can be described as follows: A traveling salesman departs from a certain city, visits two other cities to sell merchandise, and must visit each city exactly once before returning to the original starting city. The distances between the cities are provided in the table below.

City	1	2	3	4
1	0	10	20	12
2	10	0	5	10
3	20	5	0	8
4	15	12	8	0

What route should the salesman choose to travel in order to minimize the total distance? Try to formulate an integer programming model for this problem.

Consider assigning $n=2$ factories to n locations. The transportation volume between factory i and factory j is d_{ij}, and the unit transportation cost from location p to location q is c_{pq}. The specific values are shown in the following table: Table 1.1

	Transportation volume to Location 1	Transportation volume to Location 2	Transportation cost to Location 1	Transportation cost to Location 2
Factory 1	10	20	5	8
Factory 2	30	40	6	7

In order to minimize the total transportation cost, formulate this problem as an integer model.

The Li family plans to invest their retirement fund in commercial real estate. The annual income from Property 1 is $12,500, Property 2 is $35,000, Property 3 is $23,000, and Property 4 is $100,000. The decision to be made is whether to buy each property or not, rather than how many to buy, as there is only one of each property available. Help them decide which properties to purchase to maximize their annual income.

The cost of Property 1 is $1.5 million, Property 2 is $2.1 million, Property 3 is $2.3 million, and Property 4 is $4.2 million. The Li family's budget is $7 million.

If they purchase Property 4, they cannot purchase Property 3.

The Li family has 5 children: Alice, Bob, Charlie, Diana, and Ella. The cost to take Alice is $1000, Bob is $900, Charlie is $600, Diana is $500, and Ella is $700. Which children should the couple take to minimize the total cost of taking the children?

They can take up to 3 children on the upcoming trip.

Bob is the youngest, so the Li family will definitely take him.

If the couple takes Alice, they will not take Diana because Alice does not get along with her.

If the couple takes Bob, they will not take Charlie because Bob does not get along with him.

If they take Charlie, they must also take Diana.

If they take Diana, they must also take Ella.

Despite the cost, the Li family has decided to take at least two children.

A project includes the following 7 activities, with their durations (in days) as follows: $A(4), B(3), C(5), D(2), E(10), F(10), G(1)$. The precedence relationships are also given as: $A \rightarrow G, D ; E, G \rightarrow F; D, F \rightarrow C ; F \rightarrow B$. The cost of work per day is 1000 Euros; additionally, a special machine must be rented from the start of activity A to the end of activity B, costing 5000 Euros per day. Formulate this as a linear programming problem and solve it using COPTPY.

There are A and B two products, both requiring two successive chemical reaction processes. Each unit of product A needs 2 hours for the first process and 3 hours for the second process. Each unit of product B needs 3 hours for the first process and 4 hours for the second process. Available time for the first process is 16 hours, and available time for the second process is 24 hours.

For each unit of product B produced, 2 units of by-product C are generated simultaneously, requiring no additional cost. By-product C can be sold up to 5 units, and the rest must be disposed of at a cost of 2 yuan per unit.

Each unit of product A sold yields a profit of 4 yuan, each unit of product B yields a profit of 10 yuan, and each unit of by-product C sold yields a profit of 3 yuan.

In order to maximize total profit, establish the linear programming model for this problem.

A timber storage and transport company has a large warehouse for storing and transporting timber for sale. Due to seasonal price fluctuations, the company purchases timber at the beginning of each quarter, with part of it being sold within the quarter and part being stored for future sales. It is known that the maximum storage capacity of the companyâ€™s warehouse is 200,000 mÂ³, and the storage cost is $(a+b u)$ yuan/mÂ³, where $a=70$, $b=100$, and u is the storage time (in quarters). The purchase and sale prices for each quarter and the estimated maximum sales volumes are shown in Table 1-18.

Table 1-18

Quarter	Purchase Price (10,000 yuan/10,000 mÂ²)	Sale Price (10,000 yuan/10,000 mÂ²)	Estimated Maximum Sales Volume (10,000 mÂ³)
Winter	410	425	100
Spring	430	440	140
Summer	460	465	200
Autumn	450	455	160

Since timber is not suitable for long-term storage, all inventory should be sold by the end of autumn. Try to establish a linear programming model for this problem to maximize the company's annual profit.

There are 10 different parts, and they can all be processed on machine A, machine B, or machine C. The unit processing costs are shown in Table 5-6. Additionally, as long as any part is processed on the aforementioned machines, a one-time setup cost will be incurred regardless of whether one or multiple types of parts are processed, with the respective costs being $d_A = 100$, $d_B = 135$, and $d_C = 200$ yuan. If the requirements are:

1. One piece of each of the aforementioned 10 types of parts needs to be processed;
2. If the 1st part is processed on machine A, then the 2nd part must be processed on machine B or C; conversely, if the 1st part is processed on machine B or C, then the 2nd part must be processed on machine A;
3. Parts 3, 4, and 5 must be processed on machines A, B, and C respectively;
4. The number of parts processed on machine C should not exceed 3 types.

Try to establish an integer programming mathematical model for this problem with the objective of minimizing the total cost.

Table 5-6

Machine/Part	1	2	3	4	5	6	7	8	9	10
A	10	20	30	40	50	60	70	80	90	100
B	15	25	35	45	55	65	75	85	95	105
C	20	30	40	50	60	70	80	90	100	110

A shoe store employs 5 full-time sales clerks and 4 part-time sales clerks. Their working hours and wage conditions are shown in Table 3.3.

Table 3.3

	Monthly Working Hours	Sales Volume (Pairs/Hour)	Wage (Yuan/Hour)	Overtime Pay (Yuan/Hour)
Full-time	160	5	1	1.5
Part-time	80	2	0.6	0.7

Each pair of shoes sold earns a profit of 0.3 yuan. The store has set the following goals:

p_{1}: Achieve monthly sales of 5500 pairs;

p_{2}: Ensure full employment of all sales clerks;

p_{3}: Minimize overtime hours.

Try to establish a model for this problem.

A furniture factory needs to decide how many tables, chairs, and bookshelves to produce in order to maximize its profit. The factory can sell each table for $200, each chair for $50, and each bookshelf for $150. The manufacturing costs for each table, chair, and bookshelf are $120, $20, and $90 respectively. The profit is the difference between the selling price and the manufacturing cost. Each table, chair, and bookshelf occupy 5, 2, and 3 square meters of warehouse space respectively. Due to limited warehouse space, the total space cannot exceed 500 square meters. In addition, due to market demand, the factory needs to produce at least 10 tables and 20 bookshelves. Finally, the total number of items produced by the factory cannot exceed 200.

A company requires skilled workers and laborers for three tasks. The first task can be completed by one skilled worker alone, or by a group of one skilled worker and two laborers. The second task can be done by one skilled worker or one laborer alone. The third task can be completed by a group of five laborers, or by one skilled worker leading three laborers. The weekly wages for skilled workers and laborers are 100 yuan and 80 yuan respectively. They work 48 hours per week, but their actual effective working hours are 42 hours and 36 hours respectively. To complete these tasks, the company needs a total effective working time of 10,000 hours for the first task, 20,000 hours for the second task, and 30,000 hours for the third task per week. The number of workers that can be recruited is limited to a maximum of 400 skilled workers and 800 laborers. Establish a mathematical model to determine how many skilled workers and laborers should be hired in order to minimize the total wage expenditure.

On Danzig Street, vehicles can park on both sides of the street. Mr. Edmonds, who lives at No. 1, is organizing a party with about 30 participants, and they will arrive in 15 cars. The length of the i-th car is Î»_i, in meters, as follows:

i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Î»_i	4	4.5	5	4.1	2.4	5.2	3.7	3.5	3.2	4.5	2.3	3.3	3.8	4.6	3

In order to avoid disturbing the neighbors, Mr. Edmonds wants to arrange parking on both sides of the street so that the total length of the street occupied by his friends' vehicles is minimized. Please provide a mathematical programming formulation and solve this problem using AMPL.
How does the program change if the cars on one side of the street cannot occupy more than 30 meters?

Changjiang Comprehensive Shopping Mall has 5000 mÂ² of space for lease and plans to attract the following 5 types of stores as tenants. The table below shows the area occupied by each type of store for one shop, the minimum and maximum number of shops for each type within the mall, and the expected annual profit (in ten thousand yuan) per store for different numbers of stores. Each store pays 20% of its annual profit as rent to the mall. Question: How many of each type of store should the mall lease to maximize total rental income?

Table 5-12

Code	Store Type	Area per Shop / mÂ²	Min	Max	1 Store	2 Stores	3 Stores
1	Jewelry	250	1	3	9	8	7
2	Shoes & Hats	350	1	2	10	9	-
3	General Merchandise	800	1	3	27	21	20
4	Bookstore	400	0	2	16	10	-
5	Catering	500	1	3	17	15	12

A certain restaurant operates around the clock, and the number of waiters needed in 24 hours is shown in Table 1.1.

Table 1.1

Time	Minimum Number of Waiters Needed	Time	Minimum Number of Waiters Needed
$2 \sim 6$	4	$14 \sim 18$	7
$6 \sim 10$	8	$18 \sim 22$	12
$10 \sim 14$	10	$22 \sim 2$	4

Each waiter works continuously for 8 hours a day. The goal is to find the minimum number of waiters that meet the above conditions and represent this problem as a linear programming model.

and E are $8100, $20000, $21000, $3000, and $8000 respectively. They need to decide whether to hire each candidate. The team wants to minimize the total amount paid to the candidates.

They hope to hire a maximum of 3 new employees.

The team has a limited budget of $35,000. They need to ensure that the total payment to the selected candidates does not exceed the budget.

The qualifications of the five candidates are as follows:
Candidate A: Bachelor's degree;
Candidate B: Master's degree;
Candidate C: Doctoral degree;
Candidate D: No degree;
Candidate E: No degree.
They will select at least one candidate with a Master's or Doctoral degree.

The work experience of the five candidates is as follows:
Candidate A: 3 years of work experience;
Candidate B: 10 years of work experience;
Candidate C: 4 years of work experience;
Candidate D: 3 years of work experience;
Candidate E: 7 years of work experience.
They hope the total work experience of the selected candidates is no less than 12 years.

Due to the equivalent professional skills of candidates A and E, the company will choose at most one from the two.

They will hire at least 2 new employees.

A company is producing two products (X and Y). The resources required for the production of X and Y are divided into two parts: machine time for automated processing and craftsman time for manual finishing. The table below shows the number of minutes required for each product:

Item	Machine Time (minutes)	Craftsman Time (minutes)
X	13	20
Y	19	29

The company has 40 hours of machine time available in the next working week, but only 35 hours of craftsman time. The cost of machine time is Â£10 per hour, and the cost of craftsman time is Â£2 per hour. Idle time for machines and craftsmen incurs no cost. For each product produced (all products produced will be sold), the revenue for product X is Â£20, and the revenue for product Y is Â£30. The company has a specific contract that requires 10 units of product X to be produced for a customer each week. Formulate a model for this problem.

Healthy Pet Foods Company produces two types of dog food: Meaties and Yummies. Each pack of Meaties contains 2 pounds of grains and 3 pounds of meat; each pack of Yummies contains 3 pounds of grains and 1.5 pounds of meat. The company believes it can sell any quantity of dog food that it can produce. Meaties sell for $2.80 per pack, and Yummies sell for $2.00 per pack. The company's production is subject to several constraints. First, a maximum of 400,000 pounds of grains can be purchased each month at a price of $0.20 per pound of grains. A maximum of 300,000 pounds of meat can be purchased each month at a price of $0.50 per pound of meat. Additionally, a special machine is required to produce Meaties, with a monthly capacity of 90,000 packs. The variable costs for mixing and packaging dog food are $0.25 per pack (Meaties) and $0.20 per pack (Yummies). Detailed information is provided in Table B-1.

Table B-1 Healthy Pet Foods Data

	Meaties	Yummies
Price per pack	$2.80	$2.00
Raw materials		
- Grains	2.0 lbs	3.0 lbs
- Meat	3.0 lbs	1.5 lbs
Variable cost	$0.25/pack	$0.20/pack
Resources		
Meaties capacity	90,000 packs/month	
Monthly available grains	400,000 lbs	
Monthly available meat	300,000 lbs	

Assume you are the manager of the dog food department at Healthy Pet Foods Company. Your salary is based on the department's profit, so you will try to maximize profit. How should you operate the department to maximize both the profit and your salary?

A transportation company has two types of trucks, Type A and Type B. Type A trucks have 20 cubic meters of refrigerated capacity and 40 cubic meters of non-refrigerated capacity. In contrast, Type B trucks have the same total capacity, but the capacities for refrigerated and non-refrigerated cargo are equal. A grocer needs to rent trucks to transport 3000 cubic meters of refrigerated cargo and 4000 cubic meters of non-refrigerated cargo. The rental cost per kilometer for Type A trucks is Â£30, while the rental cost per kilometer for Type B trucks is Â£40. How many of each type of truck should the grocer rent to minimize the total cost?

Try to formulate a model for this problem.

A company uses two machines (Machine 1 and Machine 2) to produce two types of products (liquid fertilizer and solid fertilizer). To produce one unit of liquid fertilizer, it takes 50 minutes on Machine 1 and 30 minutes on Machine 2. To produce one unit of solid fertilizer, it takes 24 minutes on Machine 1 and 33 minutes on Machine 2. At the beginning of the week, there are 30 units of liquid fertilizer and 90 units of solid fertilizer in inventory. The available processing time for Machine 1 this week is expected to be 40 hours, and for Machine 2 it is expected to be 35 hours. The demand for liquid fertilizer this week is estimated at 75 units, and for solid fertilizer at 95 units. The company's policy is to maximize the total number of units of liquid fertilizer and solid fertilizer in inventory at the end of the week.

Formulate a model for this problem.

A company produces product A and product B. Each unit of product A sold generates a profit of Â£30, while each unit of product B sold generates a profit of Â£10. The company can allocate a maximum of 40 hours per week for production. Producing one unit of product A requires 6 hours, while producing one unit of product B requires 3 hours. Market demand requires that the quantity of product B produced must be at least three times the quantity of product A. The storage space occupied by product A is four times that of product B, and a maximum of four units of product A can be stored per week.

Formulate a model for this problem.

A store wants to clear out 200 shirts and 100 pairs of pants from last season. They decide to introduce two promotional packages, A and B. Package A includes one shirt and two pairs of pants, priced at Â£30. Package B includes three shirts and one pair of pants, priced at Â£50. The store does not want to sell fewer than 20 A packages and 10 B packages. How many of each package do they need to sell to maximize the revenue from the promotion?

Try to establish a model for this problem.

A company produces two products (A and B), with a profit of Â£3 and Â£5 per unit sold, respectively. Each product must be assembled on a specific machine, requiring 12 minutes of assembly time per unit for product A and 25 minutes per unit for product B. The company's estimated effective machine working time per week is only 30 hours (due to maintenance or malfunctions). Technical constraints mean that for every five units of product A produced, at least two units of product B must be produced.

Try to formulate a model for this problem.

A school is preparing a trip for 400 students. The transportation company has 10 buses with 50 seats each and 8 minibuses with 40 seats each, but only 9 drivers are available. The rental cost for a bus is Â£800, and the rental cost for a minibus is Â£600. Calculate how many of each type of bus should be used to achieve the lowest cost.

Try to formulate a model for this problem.

A dairy processing plant uses milk to produce two dairy products, A_{1} and A_{2}. One barrel of milk can be processed into 3 kg of A_{1} in 12 hours on Type A equipment or into 4 kg of A_{2} in 8 hours on Type B equipment. According to market demand, all produced A_{1} and A_{2} can be sold. The profit is 24 yuan per kilogram of A_{1} and 16 yuan per kilogram of A_{2}. The processing plant can get a daily supply of 50 barrels of milk, with a total of 480 hours of labor time available from regular workers each day. The Type A equipment can process up to 100 kg of A_{1} per day, while the processing capacity of Type B equipment is not limited. Formulate a production plan for the plant to maximize daily profit.

A company blends two types of crude oil (A and B) to produce two types of gasoline (Type I and Type II). The minimum proportion of crude oil A in gasoline Types I and II is 50% and 60%, respectively. The selling prices are 4800 yuan/t and 5600 yuan/t, respectively. The company has current inventories of 500 t of crude oil A and 1000 t of crude oil B, and they can purchase up to 1500 t of crude oil A from the market. The market price for crude oil A is: 10,000 yuan/t for purchases up to 500 t; 8,000 yuan/t for the portion exceeding 500 t but not exceeding 1000 t; 6,000 yuan/t for the portion exceeding 1000 t. How should the company plan its purchasing and processing of crude oil?

A beverage factory produces a kind of beverage to meet market demand. According to market forecasts, the sales department of the factory has determined the demand for the beverage for the next 4 weeks. The planning department, based on the actual situation of the factory, has provided the production capacity and production cost for the next 4 weeks, as shown in Table 1. When there is a surplus of beverages after meeting the demand each week, a storage cost of 0.2 thousand yuan per week per thousand boxes of beverages needs to be paid. How should the production plan be arranged to minimize the total cost (the sum of production cost and storage cost) over the four weeks while meeting the weekly market demand?

Table 1 Beverage Production and Demand Data:

Week	Demand/1000 boxes	Production Capacity/1000 boxes	Cost per 1000 boxes/1000 yuan
1	15	30	5.0
2	25	40	5.1
3	35	45	5.4
4	25	20	5.5
Total	100	135	

A steel pipe retailer sources raw steel pipes from a steel pipe factory, cuts the pipes according to customer requirements, and sells them. The raw steel pipes obtained from the factory are all 1850 mm in length. A customer now needs 15 pieces of 290 mm, 28 pieces of 315 mm, 21 pieces of 350 mm, and 30 pieces of 455 mm steel pipes. To simplify the production process, it is required that no more than 4 types of cutting patterns are used. The most frequently used cutting pattern incurs an additional cost of 1/10 of the value of a raw steel pipe, the second most frequent incurs an additional cost of 2/10, and so on. Moreover, the number of cuts for each pattern cannot be too many (a single raw steel pipe can produce up to 5 products). Additionally, to minimize waste, the leftover material for each cutting pattern should not exceed 100 mm. How should the material be cut to minimize total cost, and what is the total cost in this case?

A company mixes four types of liquid raw materials with different sulfur contents (denoted as A, B, C, and D, respectively) to produce two products (denoted as A and B). According to the production process requirements, raw materials A, B, and D must first be mixed in a mixing tank, and then the mixed liquid is further mixed with raw material C to produce A and B. The sulfur contents of raw materials A, B, C, and D are $3\%, 1\%, 2\%, 1\%$ respectively, and their purchase prices are 6, 16, 10, 15 (thousand yuan per ton) respectively. The sulfur content of products A and B must not exceed 2.5% and 1.5% respectively, and their selling prices are 9.15 (thousand yuan per ton). According to market information, there is no limit to the supply of raw materials A, B, and C, but the supply of raw material D is limited to a maximum of 50 tons. The market demand for products A and B is 100 tons and 200 tons respectively. How should the production be arranged?

A company uses steel and aluminum as raw materials to produce two products (A and B). A single unit of product A requires 6 kg of steel, 8 kg of aluminum, 11 hours of labor, and yields a profit of 5000 yuan (excluding worker overtime pay). A single unit of product B requires 12 kg of steel, 20 kg of aluminum, 24 hours of labor, and yields a profit of 11000 yuan (excluding worker overtime pay). The company currently has 200 kg of steel, 300 kg of aluminum, and 300 hours of labor available. If workers need to work overtime, the overtime pay is 100 yuan per hour. Please develop a production plan to maximize the company's profit and minimize worker overtime.

An electronic system is composed of 3 types of components. The system operates normally if all three components function properly. By installing one or more spare parts for any of the components, the reliability of the components can be improved. The system's operational reliability is the product of the reliabilities of each component, and the reliability of each component is a function of the number of spare parts installed. The first half of the table below shows the function relationship between the number of spare parts and the reliability of a specific component. The prices and weights of the 3 types of components are shown in rows 8 to 9 of the table. Given that the total budget for all spare parts is limited to 150 yuan, and the weight limit is 20 kg, how should spare parts be installed to maximize the system's operational reliability?

```
\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|}
\hline
\textbf{Component Number} & \textbf{1} & \textbf{2} & \textbf{3} \\ \hline
\textbf{Number of Spares} &  &  &  \\ \hline
0 & 0.5 & 0.6 & 0.7 \\ \hline
1 & 0.6 & 0.75 & 0.9 \\ \hline
2 & 0.7 & 0.95 & 1.0 \\ \hline
3 & 0.8 & 1.0 & 1.0 \\ \hline
4 & 0.9 & 1.0 & 1.0 \\ \hline
5 & 1.0 & 1.0 & 1.0 \\ \hline
\textbf{Unit Price (yuan)} & 20 & 30 & 40 \\ \hline
\textbf{Unit Weight (kg)} & 2 & 4 & 6 \\ \hline
\end{tabular}
\caption{Spare Component Data Table}
\end{table}
```

In network communication services, bandwidth plays an important role. Below is a bandwidth communication table between several communication nodes, showing the bandwidth between any two nodes. If two nodes cannot be directly connected, the corresponding bandwidth is 0. It is required to establish a link between node A and node E that must pass through service node C (without loops). The bandwidth of this link is defined as the minimum bandwidth value on the link. Please propose a reasonable link arrangement to maximize the bandwidth of this link and find out the maximum bandwidth.

```
\begin{table}[h]
  \centering
  \begin{tabular}{|c|c|c|c|c|c|}
    \hline
    & A & B & C & D & E \\
    \hline
    A & 0 & 90 & 85 & 0 & 65 \\
    \hline
    B & 95 & 0 & 70 & 65 & 34 \\
    \hline
    C & 60 & 0 & 0 & 88 & 80 \\
    \hline
    D & 67 & 30 & 25 & 0 & 84 \\
    \hline
    E & 0 & 51 & 0 & 56 & 0 \\
    \hline
  \end{tabular}
\end{table}
```

en_answer	difficulty	id
219816	Medium	1

125	Medium	2

10349920	Hard	3

30400	Easy	4

1600	Easy	5

10755	Hard	6

904590	Medium	7

14	Medium	8

623	Hard	9

3	Easy	10

4136	Medium	11

43200	Hard	12

180000	Medium	13

123.8	Hard	14

36	Medium	15

4100	Easy	16

0.5765	Hard	17

227500	Medium	18

4000 Easy 19

956	Easy	20

1000	Easy	21

21500	Easy	23

1000	Easy	24

510000	Easy	25

53	Hard	26

1146.414	Hard	27

580000	Medium	28

11500	Medium	29

32.4359	Easy	30

1190.41	Hard	31

2924 Easy 32

1000	Medium	33

7 Hard 34

14.1 Medium 35

175.37	Hard	36

11250	Medium	37

14	Easy	38

600 Easy 39

33288067	Medium	40

96.464	Medium	41

150	Easy	42

6800 Medium	43

685	Medium	44

734	Easy	45

472.3	Medium	46

20241.62	Hard	47

11250	Medium	48

56000	Easy	49

9100	Easy	50

4240	Medium	51

150	Easy	52

3050	Easy	53

135.2667	Easy	54

4 Hard 55

1360.45	Medium	56

600 Easy 57

264000	Easy	58

6160 Medium 59

153	Hard	60

37000	Easy	61

90000	Easy	62

640	Easy	63

38000	Easy	64

30500	Medium	65

25000	Medium	66

3160500	Medium	67

1030	Easy	68

20	Easy	69

35	Easy	70

330	Medium	71

135000	Easy	72

1200 Easy 73

230000	Medium	74

57	Easy	75

4700	Medium	76

1000 Easy 77

400	Medium	78

9800 Easy 79

45960	Medium	80

28.6	Hard	81

28	Easy	82

26	Hard	83

23000	Easy	84

1866.37	Hard	85

77500 Hard 86

4170	Medium	87

1.25	Medium	88

146.667	Medium	89

4000	Medium	90

6200	Easy	91

408.9	Easy	92

3360 Easy 93

4800000	Medium	94

528	Medium	95

19.6	Medium	96

450	Medium	97

137500	Medium	98

0.6075	Hard	99

84	Hard	100