NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

MODELLING AND SIMULATION LABORATORY
Assignment 1

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ASSIGNMENT : 1

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Q.1)

Problem 1

A person requires 10, 12 and 12 units of chemicals A, B and C respectively for his gardens. A liquid product contains 5, 2 and 1 units of A, B and C respectively per jar. A dry product contains 1, 2 and 4 units of A, B and C per carton. If the liquid product sells for | 3 per jar and the dry product sells for | 2 per carton, how many of each should be purchased to optimize the cost and meet the requirements? Formulate the problem as a LPP and solve it by graphical method.

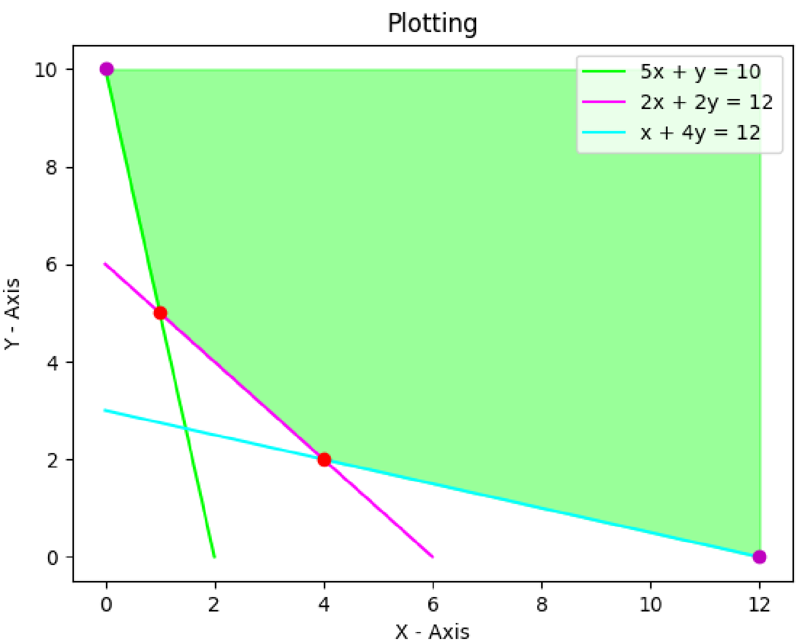
Code :

```
   #code by ROMIJUL LASKAR 20CS8065

from shapely.geometry import LineString
from matplotlib import pyplot as plt

def plot_line(x, y, color, label):
    plt.plot(x, y, color=color, label=label)

def plot_intersection(line1, line2):
    intersection = line1.intersection(line2)
    plt.plot(*intersection.xy, 'ro')
    return intersection

def plot_fill_between(x, y, color, alpha):
    plt.fill_between(x, y, max(y), color=color, alpha=alpha)

def print_basis(lines):
    basis = []
    for line in lines:
        basis.append((line.coords[1], line.coords[0]))
    basis.sort(key=lambda p: (p[0][0], p[0][1]))
    print("Basis of the graph:")
    for point1, point2 in basis:
        print(f"({point1[0]}, {point1[1]}) -> ({point2[0]}, 
{point2[1]})")

# User input for points
x1 = [int(x) for x in input("Enter x-coordinates for line 1 (separated 
by space): ").split()]
y1 = [int(y) for y in input("Enter y-coordinates for line 1 (separated 
by space): ").split()]
```

```
x2 = [int(x) for x in input("Enter x-coordinates for line 2 (separated by space): ").split()]
y2 = [int(y) for y in input("Enter y-coordinates for line 2 (separated by space): ").split()]

x3 = [int(x) for x in input("Enter x-coordinates for line 3 (separated by space): ").split()]
y3 = [int(y) for y in input("Enter y-coordinates for line 3 (separated by space): ").split()]

plot_line(x1, y1, color='lime', label='5x + y = 10')
plot_line(x2, y2, color='magenta', label='2x + 2y = 12')
plot_line(x3, y3, color='cyan', label='x + 4y = 12')

plt.xlabel('X - Axis')
plt.ylabel('Y - Axis')
plt.title('Plotting')
plt.legend()

line1 = LineString(list(zip(x1, y1)))
line2 = LineString(list(zip(x2, y2)))
line3 = LineString(list(zip(x3, y3)))

intersection1 = plot_intersection(line1, line2)
intersection2 = plot_intersection(line2, line3)

x = [0, intersection1.x, intersection2.x, 12]
y = [10, intersection1.y, intersection2.y, 0]
plot_fill_between(x, y, color='lime', alpha=0.4)  # Neon green

print("Point of Intersection 1:")
print(intersection1.x, intersection1.y)
print("Point of Intersection 2:")
print(intersection2.x, intersection2.y)

lines = [line1, line2, line3]
print_basis(lines)
plt.show()
```

Output :

```
Enter x-coordinates for line 1 (separated by space): 0 2
Enter y-coordinates for line 1 (separated by space): 10 0
Enter x-coordinates for line 2 (separated by space): 0 6
Enter y-coordinates for line 2 (separated by space): 6 0
Enter x-coordinates for line 3 (separated by space): 0 12
Enter y-coordinates for line 3 (separated by space): 3 0
Point of Intersection 1:
1.0 5.0
Point of Intersection 2:
4.0 2.0
Basis of the graph:
(2.0, 0.0) -> (0.0, 10.0)
(6.0, 0.0) -> (0.0, 6.0)
(12.0, 0.0) -> (0.0, 3.0)
```



Assignment - 1

Problem: 1 20CS8065 - Romijul Laskar

A person requires 10, 12 and 12 units of chemicals A, B and C respectively for his gardens. A liquid product contains 5, 2, and 1 units of A, B and C respectively per jar. A dry product contains 1, 2 and 4 units of A, B and C per carton. If the liquid product sells for ₹3 per jar and the dry products sells for ₹2 per carton, how many of each should be purchased to optimize the cost and meet the requirements? Formulate the problem as a LPP and solve it by graphical method.

⟹

Let x and y be the no of unit for liquid and dry products.

Chemical	Liquid pro:	Dry Pro:	Requirement
A	5	1	10
B	2	2	12
C	1	4	12

Objective function: Minimize:

$$Z = 3x + 2y$$

Constraint for chemical A: $5x + y \geq 10$

" " " B: $2x + 2y \geq 12$

" " " C: $x + 4y \geq 12$

Non negative, $x \geq 0$, $y \geq 0$

So, the LPP is of this model is

$$Z = 3x + 2y$$

→ $5x + y \geq 10$,
$2x + 2y \geq 12$,
$x + 4y \geq 12$,
when $x \geq 0, y \geq 0$

Numbering the equations

$$5x + y = 10 \quad \text{--- (i)}$$
$$2x + 2y = 12 \quad \text{--- (ii)}$$
$$x + 4y = 12 \quad \text{--- (iii)}$$
$$x = y = 0$$

To get the graph of eq (i), we put $x=0$, $y=0$, we get

$x=0$: $5 \cdot 0 + y = 10$

$\Rightarrow y = 10$

so the point $(0, 10)$

$y=0$:

$5x + 0 = 10$

$5x = 10 \Rightarrow x = 2$

the point $(2, 0)$

Similarly for eq (ii):

$x:0$,

$2 \cdot 0 + 2y = 12$

$2y = 12$

$\Rightarrow y = 6$

$(0, 6)$

$y:0$

$2x + 2 \cdot 0 = 12$

$\Rightarrow x = 6$

$(6, 0)$

Similarly for eq (iii):

$x:0$

$0 + 4y = 12$

$\Rightarrow y = 3$

$(0, 3)$

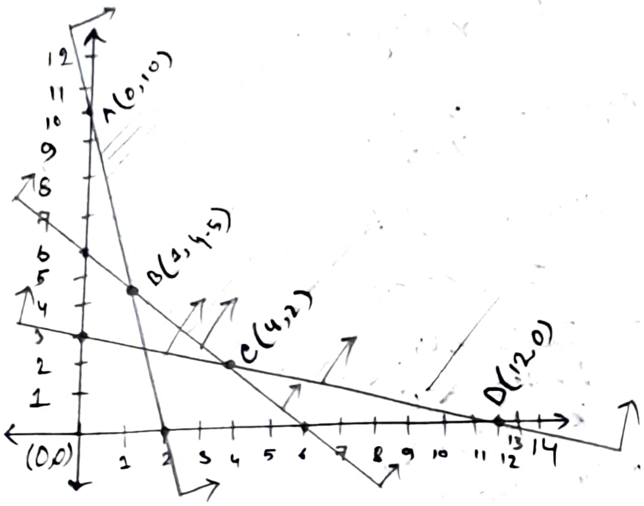
$y:0$:

$x + 4 \cdot 0 = 12$

$\Rightarrow x = 12$

$(12, 0)$

Now plotting these lines:



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So the Common region for all the line pointed on the graphs beyonds the line of eqn (i), (ii), (iii), marked by the shaded region.

Now from the corner point of the unbounded solution of graph i.e. point A, B, C, D, we put the value of these point into objective function to get the solution (minimize Z).

$A(0,10) \rightarrow Z = 3\cdot 0 + 10\cdot 2 = 20$

$B(1,5) \rightarrow Z = 3\cdot 1 + 2\cdot 5 = 13$

$C(4,2) \rightarrow Z = 3\cdot 4 + 2\cdot 2 = 17$

$D(12,0) \rightarrow Z = 3\cdot 12 + 2\cdot 0 = 36$.

So, $Z = \min(20, 13, 17, 36)$

$= 13$

So, Z is minimum in $B = 13$.

Q.2)

Problem 2

A company produces 2 types of hats. Every hat H1 requires twice as much labour as the second hat H2. If the company produces only hat H2 then it can produce a total of 500 hats a day. The market limits daily sales of hat H1 and H2 to 150 and 250 respectively. The profit on hat H1 and H2 are ₹ 8 and ₹ 5 respectively. Formulate the problem as an LPP and find the optimal solution using graphical method.

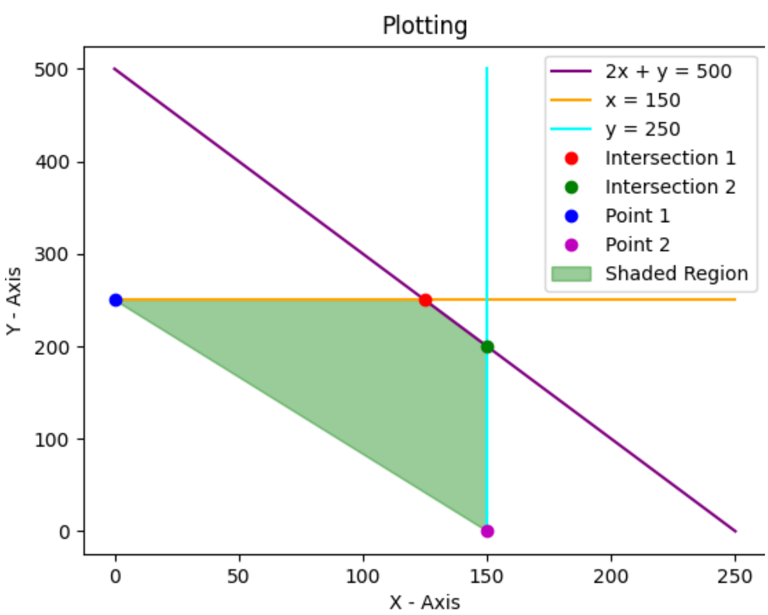
Code:

```
#code by Romijul Laskar 20CS8065
from shapely.geometry import LineString
from matplotlib import pyplot as plt

def plot_graph(points):
    x = []
    y = []
    for p in points:
        x.append(p[0])
        y.append(p[1])


    plt.plot(x[:2], y[:2], color='purple', label='2x + y = 500')
    plt.plot(x[2:4], y[2:4], color='orange', label='x = 150')
    plt.plot(x[4:6], y[4:6], color='cyan', label='y = 250')

    plt.xlabel('X - Axis')
    plt.ylabel('Y - Axis')
    plt.title('Plotting')

    line1 = LineString([(x[0], y[0]), (x[1], y[1])])
    line2 = LineString([(x[2], y[2]), (x[3], y[3])])
    line3 = LineString([(x[4], y[4]), (x[5], y[5])])


    intersection = line1.intersection(line3)
    plt.plot(*intersection.xy, 'ro', label='Intersection 1')

    intersection2 = line1.intersection(line2)
    plt.plot(*intersection2.xy, 'go', label='Intersection 2')


    plt.plot(x[4], y[4], 'bo', label='Point 1')
    plt.plot(x[2], y[2], 'mo', label='Point 2')


    x_fill = [x[4], intersection.xy[0][0], intersection2.xy[0][0], x[2]]
    y_fill = [y[4], intersection.xy[1][0], intersection2.xy[1][0], y[2]]

    plt.fill(x_fill, y_fill, color='green', alpha=0.4, label='Shaded 
Region')
```

```
    plt.legend()

    plt.show()


    print("Point of Intersection 1: ")
    print(intersection.xy[0][0])
    print(intersection.xy[1][0])
    print("Point of Intersection 2: ")
    print(intersection2.xy[0][0])
    print(intersection2.xy[1][0])


    z = []
    for i in range(0, 4):
        eqn = 8 * x[i+2] + 5 * y[i+2]
        z.append(eqn)
        print("Z =", z)


    max_val = max(z)
    xy_index = z.index(max_val)
    print("The Value of Z =", max_val, "at point (", x[xy_index+2], ",",
y[xy_index+2], ")")

points = [(250, 0), (0, 500), (0, 250), (250, 250), (150, 0), (150,
500)]
plot_graph(points)
```

Output:

```
Point of Intersection 1:
125.0
250.0
Point of Intersection 2:
150.0
200.0
Z = [1250]
Z = [1250, 2250.0]
Z = [1250, 2250.0, 2200.0]
Z = [1250, 2250.0, 2200.0, 1200]
The Value of Z = 2250.0 at point ( 125.0 , 250.0 )
```



Problem : 2

A Company produces 2 types of hats. Every hat H_1 requires twice as much labor as the second hat H_2. If the Company produces only hat H_2 then it can produce a total of 500 hats a day. The market limits daily sales of ~~that~~ hat H_1 and H_2 to 150 and 250 respectively. The profit on hat H_1 and H_2 are ₹ 8 and ₹ 5 respectively. Formulate the problem as a LPP and find the optimal solution using graphical method.

⇒ Let the company produce ~~company~~ x hat h_1 and y hat h_2, so the profit P after selling these two product →

$$P = 8x + 5y \text{ (objective function)}$$

Production restriction given $2tx + ty \leq 500t$, where t is the labour time per unit of second type.

$$2x + y \leq 500$$

But, the limitation on the sale growth, therefore further restrictions are $x \leq 150$, $y \leq 250$

$\therefore x \geq 0$ & $y \geq 0$

So the final formulation is $P = 8x + 5y$ maximum

in restriction, $2x + y < 500$

$x < 150$

$y < 250$

$x > 0, y > 0.$

Solution

To plot these constraints on graph, these are expressed in the form of following equation :

$2x + y = 500$ --(i)

$x = 150$ ---(ii)

$y = 250$ --- (iii)

If $x = 0$, $2 \cdot 0 + y = 500$

$\Rightarrow y = 500$, $(0, 500)$

if $y = 0$,

$2x + 0 = 500$

$\Rightarrow x = 250$

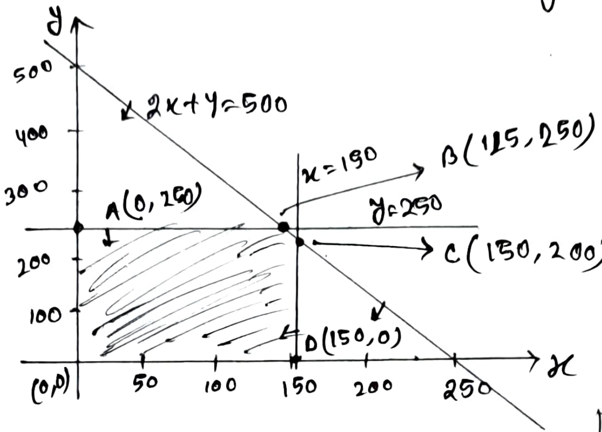
$(250, 0)$

Now for eq (ii) I can see for any value of y, x is 150, so it will plot a parallel line to y-axis at $x = 150$

Similarly for eq (iii), $x, y \geq 250$

x axis at $y = 250$.

Now plotting these above points on graph



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The common region for the three equation line are shaded which is a bounded solution,

putting the values.

$P = 8x + 5y$

(A) (0, 250) → $P = 8 \cdot 0 + 5 \cdot 250 = 1250$

(B) (125, 250) → $P = 8 \cdot 125 + 5 \cdot 250 = 2250$

(C) (150, 200) → $P = 8 \cdot 150 + 5 \cdot 200 = 2200$

(D) (150, 0) → $P = 8 \cdot 150 + 5 \cdot 0 = 1200$

Maximum $P = \{max\}(1250, 2250, 2200, 1200)$

$P = \cancel{2200}\ 2250$

So, P is maximum at B = 2250, i.e B (125, 250) that means the company produce 125 H_1 hats and 250 H_2 hats to get maximum profit.