

	LINEAR PROGRAMMING	
	Convert the following LPP in the Standard form	
	Question	Ans.
1	<p><i>Minimise</i> $z = -3x_1 + 2x_2 - x_3$</p> <p><i>subject to</i> $x_1 - 3x_2 + 2x_3 \geq -6$</p> $3x_1 + 4x_3 \leq 3$	<p><i>Maximise</i> $z' = 3x_1 - 2x_2 + x_3' - x_3'' + 0s_1 + 0s_2 + 0s_3$</p> <p><i>subject to</i> $-x_1 + 3x_2 - 2x_3' + 2x_3'' + s_1 = 6$</p> $3x_1 + 4x_3' - 4x_3'' + s_2 = 3$
	$-3x_1 + 5x_2 \leq 4$	$-3x_1 + 5x_2 + s_3 = 4$
	$x_1, x_2 \geq 0, x_3 \text{ unrestricted}$	$x_1, x_2, x_3', x_3'', s_1, s_2, s_3 \geq 0]$
2	<p><i>Maximise</i> $z = 3x_1 + 4x_2 - 2x_3$</p> <p><i>subject to</i> $6x_1 - 4x_2 \leq 5$</p> $3x_1 + x_2 + 4x_3 \geq 11$	<p><i>Maximise</i> $z = 3x_1 + 4x_2 - 2x_3' + 2x_3'' + 0s_1 + 0s_2 + 0s_3$</p> <p><i>subject to</i> $6x_1 - 4x_2 + s_1 = 5$</p> $3x_1 + x_2 + 4x_3' - 4x_3'' - s_2 = 11$
	$4x_1 + 3x_2 \leq 2$	$4x_1 + 3x_2 + s_3 = 2$
	$x_1, x_2 \geq 0$	$x_1, x_2, x_3', x_3'', s_1, s_2, s_3 \geq 0]$
	Determine all basic solutions to the following problem	
	Question	Ans.
3	<p><i>Maximise</i> $z = x_1 - 2x_2 + 4x_3$</p> <p><i>subject to</i> $x_1 + 2x_2 + 3x_3 = 7$</p> $3x_1 + 4x_2 + 6x_3 = 15$	$x_1 = 1, x_2 = 3$ $x_1 = 1, x_3 = 2$ $x_2, x_3 \text{ unbounded solution}]$
4	<p><i>Maximise</i> $z = x_1 + 3x_2 + 3x_3$</p> <p><i>subject to</i> $x_1 + 2x_2 + 3x_3 = 4$</p> $2x_1 + 3x_2 + 5x_3 = 7$	$x_1 = 2, x_2 = 1$ $x_1 = 1, x_3 = 1$ $x_2 = -1, x_3 = 2]$
5	<p><i>Maximise</i> $z = 2x_1 - 2x_2 + 4x_3 - 5x_4$</p> <p><i>subject to</i> $x_1 + 4x_2 - 2x_3 + 8x_4 \leq 2$</p> $-x_1 + 2x_2 + 3x_3 + 4x_4 \leq 1$	$x_1 = 0, x_2 = 1/2, x_1 = 0, x_4 = 1/4$ $x_1 = 8, x_3 = 3, x_2, x_4 = \text{unbounded}$ $x_2 = 1/2, x_3 = 0, x_3 = 0, x_4 = 1/4]$
	$x_1, x_2, x_3, x_4 \geq 0$	
6	<p><i>Maximise</i> $z = x_1 + x_2 + 3x_3$</p> <p><i>subject to</i> $x_1 + 2x_2 + 3x_3 = 9$</p> $3x_1 + 2x_2 + 2x_3 = 15$	$x_1 = 3, x_2 = 3$ $x_1 = 27/7, x_3 = 12/7$ $x_2 = 27/2, x_3 = -6]$

	Solve the following linear programming problems by Simplex method	
7	<p><i>Maximise</i> $z = 5x_1 + 4x_2$ <i>subject to</i> $6x_1 + 4x_2 \leq 24$ $x_1 + 2x_2 \leq 6$ $-x_1 + x_2 \leq 1$ $x_2 \leq 2$ $x_1, x_2 \geq 0$ [Ans: $x_1 = 3, x_2 = 3/2, z_{\max} = 21$]</p>	<p>8 <i>Maximise</i> $z = 4x_1 + 10x_2$ <i>subject to</i> $2x_1 + x_2 \leq 50$ $2x_1 + 5x_2 \leq 100$ $2x_1 + 3x_2 \leq 90$ $x_1, x_2 \geq 0$ [Ans: $x_1 = 0, x_2 = 20, z_{\max} = 200$]</p>
9	<p><i>Maximise</i> $z = 6x_1 - 2x_2 + 3x_3$ <i>subject to</i> $2x_1 - x_2 + 2x_3 \leq 2$ $x_1 + 4x_3 \leq 4$ $x_1, x_2, x_3 \geq 0$ Ans: $x_1 = 4, x_2 = 6, x_3 = 0, z_{\max} = 12$</p>	<p>10. <i>Maximise</i> $z = 3x_1 + 2x_2$ <i>subject to</i> $x_1 + x_2 \leq 4$ $x_1 - x_2 \leq 2$ $x_1, x_2 \geq 0$ [Ans: $x_1 = 3, x_2 = 1, z_{\max} = 11$]</p>
11	<p><i>Maximise</i> $z = 3x_1 + 2x_2 + 5x_3$ <i>subject to</i> $x_1 + 2x_2 + x_3 \leq 430$ $3x_1 + 2x_3 \leq 460$ $x_1 + 4x_2 \leq 420$ $x_1, x_2, x_3 \geq 0$ Ans: $x_1 = 0, x_2 = 100, x_3 = 230, z_{\max} = 1350$</p>	<p>12. <i>Minimise</i> $z = x_1 - 3x_2 + 3x_3$ <i>subject to</i> $3x_1 - x_2 + 2x_3 \leq 7$ $2x_1 - 4x_2 \geq -12$ $-4x_1 + 3x_2 + 8x_3 \leq 10$ $x_1, x_2, x_3 \geq 0$ Ans: $x_1 = 4, x_2 = 5, x_3 = 0, z_{\min} = -z'_{\max} = -11$]</p>
13	<p><i>Maximise</i> $z = 100x_1 + 50x_2 + 50x_3$ <i>subject to</i> $4x_1 + 3x_2 + 2x_3 \leq 10$ $3x_1 + 8x_2 + x_3 \leq 8$ $4x_1 + 2x_2 + x_3 \leq 6$ $x_1, x_2, x_3 \geq 0$ Ans: $x_1 = 1/2, x_2 = 0, x_3 = 4, z_{\max} = 250$]</p>	<p>14. <i>Maximise</i> $z = 3x_1 + 2x_2 + 5x_3$ <i>subject to</i> $x_1 + x_2 + x_3 \leq 9$ $2x_1 + 3x_2 + 5x_3 \leq 30$ $2x_1 - x_2 - x_3 \leq 8$ $x_1, x_2, x_3 \geq 0$ Ans: $x_1 = 5, x_2 = 0, x_3 = 4, z_{\max} = 3200/3$]</p>

15	<p><i>Maximise</i> $z = 4x_1 + 3x_2 + 6x_3$ <i>subject to</i> $2x_1 + 3x_2 + 2x_3 \leq 440$ $4x_1 + 3x_3 \leq 470$ $2x_1 + 5x_2 \leq 430$ $x_1, x_2, x_3 \geq 0$</p> <p>Ans. $x_1 = 0, x_2 = 380/9, x_3 = 470/3$ $z_{\max} = 3200/3$]</p>	<p><i>Maximise</i> $z = 4x_1 + 10x_2$ <i>subject to</i> $2x_1 + x_2 \leq 10$ $2x_1 + 5x_2 \leq 20$ $2x_1 + 3x_2 \leq 18$ $x_1, x_2 \geq 0$</p> <p>16. Ans $x_1 = 15/4, x_2 = 5/2, z_{\max} = 40$</p>
17	<p><i>Maximise</i> $z = 4x_1 + x_2 + 3x_3 + 5x_4$ <i>subject to</i> $-4x_1 + 6x_2 + 5x_3 + 4x_4 \leq 20$ $-3x_1 - 2x_2 + 4x_3 + x_4 \leq 10$ $-8x_1 - 3x_2 + 3x_3 + 2x_4 \leq 20$ $x_1, x_2, x_3, x_4 \geq 0$</p> <p>Ans: <i>unbounded solution</i></p>	<p>18. <i>Maximise</i> $z = 107x_1 + x_2 + 2x_3$ <i>subject to</i> $14x_1 + x_2 - 6x_3 + 3x_4 = 7$ $16x_1 + (1/2)x_2 - 6x_3 \leq 5$ $3x_1 - x_2 - x_3 \leq 0$ $x_1, x_2, x_3, x_4 \geq 0$</p> <p>Ans: <i>unbounded solution</i></p>
19	<p><i>Maximise</i> $z = 100x_1 + 40x_2$ <i>subject to</i> $10x_1 + 4x_2 \leq 2000$ $3x_1 + 2x_2 \leq 900$ $6x_1 + 12x_2 \leq 3000$ $x_1, x_2 \geq 0$</p> <p>Has it an alternative optima? [Ans: $x_1 = 200, x_2 = 0, z_{\max} = 2000$ <i>alternate optima</i> $x_1 = 125, x_2 = 187.5$]</p>	<p>20 <i>Maximise</i> $z = 3x_1 + 5x_2 + 4x_3$ <i>subject to</i> $2x_1 + 3x_2 \leq 8$ $2x_2 + 5x_3 \leq 10$ $3x_1 + 2x_2 + 4x_3 \leq 15$ $x_1, x_2, x_3 \geq 0$</p> <p>Ans. $x_1 = 89/41, x_2 = 50/41, x_3 = 62/41$ $z_{\max} = 765/41$]</p>
Solve the following linear programming problems by Penalty (Big-M) method		
21	<p><i>Maximise</i> $z = 3x_1 - x_2$ <i>subject to</i> $2x_1 + x_2 \geq 2$ $x_1 + 3x_2 \leq 3$ $x_2 \leq 4$ $x_1, x_2 \geq 0$</p> <p>[Ans: $x_1 = 3, x_2 = 0, z_{\max} = 9$]</p>	<p>22 <i>Maximise</i> $z = 3x_1 - x_2$ <i>subject to</i> $2x_1 + x_2 \leq 2$ $x_1 + 3x_2 \geq 3$ $x_2 \leq 4$ $x_1, x_2 \geq 0$</p> <p>[Ans: $x_1 = 3/5, x_2 = 4/5, z_{\max} = 1$</p>

23	<p><i>Maximise</i> $z = 5x_1 - 2x_2 + 3x_3$ <i>subject to</i> $2x_1 + 2x_2 - x_3 \geq 2$ $3x_1 - 4x_2 \leq 3$ $x_2 + 3x_3 \leq 5$ $x_1, x_2, x_3 \geq 0$</p> <p>Ans: $x_1 = 23/3, x_2 = 5, x_3 = 0 \quad z_{\max} = 85/3$</p>	24	<p><i>Minimise</i> $z = x_1 + 2x_2 + x_3$ <i>subject to</i> $x_1 + \frac{1}{2}x_2 + \frac{1}{2}x_3 \leq 1$ $\frac{3}{2}x_1 + 2x_2 + x_3 \geq 8$ $x_1, x_2, x_3 \geq 0$</p> <p>[Ans: No feasible solution]</p>
25	<p><i>Minimise</i> $z = 4x_1 + x_2$ <i>subject to</i> $3x_1 + x_2 = 3$ $4x_1 + 3x_2 \geq 6$ $x_1 + 2x_2 \leq 4$ $x_1, x_2 \geq 0$</p> <p>Ans: $x_1 = 2/5, x_2 = 9/5 \quad z_{\min} = 17/5$]</p>	26	<p><i>Maximise</i> $z = 10x_1 + 3x_2$ <i>subject to</i> $x_1 + 2x_2 \geq 3$ $x_1 + 4x_2 \geq 4$ $x_1, x_2 \geq 0$</p> <p>Ans: $x_1 = 0, x_2 = 3/2 \quad z_{\min} = 9/2$</p>
27	<p><i>Minimise</i> $z = 2x_1 + x_2$ <i>subject to</i> $3x_1 + x_2 = 3$ $4x_1 + 3x_2 \geq 6$ $x_1 + 2x_2 \leq 3$ $x_1, x_2 \geq 0$</p> <p>Ans: $x_1 = 3/5, x_2 = 6/5 \quad z_{\min} = 12/5$</p>	28	<p><i>Minimise</i> $z = 2x_1 + 3x_2$ <i>subject to</i> $x_1 + x_2 \geq 5$ $x_1 + 2x_2 \geq 6$ $x_1, x_2 \geq 0$</p> <p>Ans: $x_1 = 4, x_2 = 1 \quad z_{\min} = 11$</p>
29	<p><i>Minimise</i> $z = x_1 - 3x_2 - 2x_3$ <i>subject to</i> $3x_1 - x_2 + 2x_3 \geq 7$ $-2x_1 + 4x_2 \leq 12$ $-4x_1 + 3x_2 + 8x_3 \leq 10$ $x_1, x_2, x_3 \geq 0$</p> <p>[Ans: $x_1 = 78/25, x_2 = 114/25, x_3 = 11/10$ $z_{\min} = -319/25]$</p>	30	<p><i>Maximise</i> $z = 4x_1 + 5x_2 + 2x_3$ <i>subject to</i> $2x_1 + x_2 + x_3 \leq 10$ $x_1 + 3x_2 + x_3 \leq 12$ $x_1 + x_2 + x_3 = 6$ $x_1, x_2, x_3 \geq 0$</p> <p>[Ans: $x_1 = 3, x_2 = 3, x_3 = 0 \quad z_{\max} = 27$]</p>
31	<p><i>Maximise</i> $z = 6x_1 + 4x_2$ <i>subject to</i> $2x_1 + 3x_2 \leq 30$ $3x_1 + 2x_2 \leq 24$ $x_1 + x_2 \geq 3$ $x_1, x_2 \geq 0$</p> <p>Is the solution unique? If not, find another solution.</p>		

	<p>If the requirement vector $\begin{bmatrix} 30 \\ 24 \\ 3 \end{bmatrix}$ is changed to $\begin{bmatrix} 24 \\ 30 \\ 3 \end{bmatrix}$ is the solution still optimal?</p> <p>Ans: $x_1 = 8, x_2 = 0, z_{\max} = 48$</p> <p>The alternate optimal basic feasible solution is $x_1 = 12/5, x_2 = 42/5, z_{\max} = 48$</p>	
	Construct the Dual of the following LPP	
	Question	Ans.
32	<p><i>Minimise</i> $z = x_2 + 3x_3$</p> <p><i>subject to</i> $2x_1 + x_2 \leq 3$</p> $x_1 + 2x_2 + 6x_3 \geq 5$ $-x_1 + x_2 + 2x_3 = 2$ $x_1, x_2, x_3 \geq 0$	<p><i>Maximise</i> $w = -3y_1 + 5y_2 + 2y_3$</p> <p><i>subject to</i> $-2y_1 + y_2 - y_3 \leq 0$</p> $-y_1 + 2y_2 + y_3 \leq 1$ $6y_2 + 2y_3 \leq 3$ $y_1, y_2 \geq 0, y_3 \text{ unrestricted]}$
33	<p><i>Minimise</i> $z = 3x_1 - 2x_2 + x_3$</p> <p><i>subject to</i> $2x_1 - 3x_2 + x_3 \leq 5$</p> $4x_1 - 2x_2 \geq 9$ $-8x_1 + 4x_2 + 3x_3 = 8$ $x_1, x_2 \geq 0, x_3 \text{ unrestricted}$	<p><i>Maximise</i> $w = -5y_1 + 9y_2 + 8y_3$</p> <p><i>subject to</i> $-2y_1 + 4y_2 - 8y_3 \leq 3$</p> $3y_1 - 2y_2 + 4y_3 \leq -2$ $-y_1 + 3y_3 = 1$ $y_1, y_2 \geq 0, y_3 \text{ unrestricted]}$
34	<p><i>Maximise</i> $z = 3x_1 + 17x_2 + 9x_3$</p> <p><i>subject to</i> $-x_2 + x_3 \geq 3$</p> $-3x_1 + 2x_3 \leq 1$ $2x_1 + x_2 - 5x_3 = 1$ $x_1, x_2, x_3 \geq 0$	<p><i>Minimise</i> $w = -3y_1 + y_2 + y_3$</p> <p><i>subject to</i> $-y_1 - 3y_2 + 2y_3 \geq 3$</p> $y_1 + y_3 \geq 17$ $-y_1 + 2y_2 - 5y_3 \geq 19$ $y_1, y_2 \geq 0, y_3 \text{ unrestricted]}$
35	<p><i>Maximise</i> $z = 2x_1 - x_2 + 3x_3$</p> <p><i>subject to</i> $x_1 - 2x_2 + x_3 \geq 4$</p> $2x_1 + x_3 \leq 10$ $x_1 + x_2 + 3x_3 = 20$ $x_1, x_3 \geq 0, x_2 \text{ unrestricted}$	<p><i>Minimise</i> $w = -4y_1 + 10y_2 + 20y_3$</p> <p><i>subject to</i> $-y_1 + 2y_2 + y_3 \geq 2$</p> $2y_1 + y_3 = -1$ $-y_1 + y_2 + 3y_3 \geq 3$ $y_1, y_2 \geq 0, y_3 \text{ unrestricted]}$

36	<p><i>Minimise</i> $z = x_1 - 3x_2 - 2x_3$</p> <p><i>subject to</i> $3x_1 - x_2 + 2x_3 \leq 7$</p> <p>$2x_1 - 4x_2 \geq 12$</p> <p>$-4x_1 + 3x_2 + 8x_3 = 10$</p> <p>$x_1, x_2 \geq 0, x_3$ <i>unrestricted</i></p>	<p><i>Maximise</i> $w = -7y_1 + 12y_2 + 10y_3$</p> <p><i>subject to</i> $-3y_1 + 2y_2 - 4y_3 \leq 1$</p> <p>$y_1 - 4y_2 + 3y_3 \leq -3$</p> <p>$-2y_1 + 8y_3 = -2$</p> <p>$y_1, y_2 \geq 0, y_3$ <i>unrestricted</i>]</p>
37	<p><i>Maximise</i> $z = 2x_1 + x_2 + x_3$</p> <p><i>subject to</i> $x_1 + x_2 + x_3 \geq 6$</p> <p>$3x_1 - 2x_2 + 3x_3 = 3$</p> <p>$-4x_1 + x_3 \leq 10$</p> <p>$x_1, x_3 \geq 0, x_2$ <i>unrestricted</i></p>	<p><i>Minimise</i> $w = -6y_1 + 3y_2 + 10y_3$</p> <p><i>subject to</i> $-y_1 + 3y_2 - 4y_3 \geq 2$</p> <p>$-y_1 - 2y_2 = 1$</p> <p>$-y_1 + 3y_2 + y_3 \geq 1$</p> <p>$y_1, y_3 \geq 0, y_2$ <i>unrestricted</i>]</p>
38	<p><i>Maximise</i> $z = 2x_1 + 9x_2 + 11x_3$</p> <p><i>subject to</i> $x_1 - x_2 + x_3 \geq 3$</p> <p>$-3x_1 + 2x_3 \leq 1$</p> <p>$2x_1 + x_2 - 5x_3 = 1$</p> <p>$x_1, x_2, x_3 \geq 0$</p>	<p><i>Minimise</i> $w = -3y_1 + y_2 + y_3$</p> <p><i>subject to</i> $-y_1 - 3y_2 + 4y_3 \geq 2$</p> <p>$y_1 + y_2 \geq 9$</p> <p>$-y_1 + 2y_2 - 5y_3 \geq 11$</p> <p>$y_1, y_2 \geq 0, y_3$ <i>unrestricted</i>]</p>
Using Duality Solve the following linear programming problem		
39	<p><i>Minimise</i> $z = 4x_1 + 3x_2 + 6x_3$</p> <p><i>subject to</i> $x_1 + x_3 \geq 2$</p> <p>$x_2 + x_3 \geq 5$</p> <p>$x_2 \leq 4$</p> <p>$x_1, x_2, x_3 \geq 0$</p> <p>[Ans: $x_1 = 0, x_2 = 3, x_3 = 2, z_{\min} = 21$</p>	<p>40</p> <p><i>Minimise</i> $z = 5x_1 + 8x_2$</p> <p><i>subject to</i> $x_1 + x_2 \leq 2$</p> <p>$x_1 + 2x_2 \geq 0$</p> <p>$-x_1 + 4x_2 \leq 1$</p> <p>$x_1, x_2 \geq 0$</p> <p>[Ans: $x_1 = 0, x_2 = 0, z_{\min} = 0$]</p>
41	<p><i>Minimise</i> $z = 430x_1 + 460x_2 + 420x_3$</p> <p><i>subject to</i> $x_1 + 3x_2 + 4x_3 \geq 3$</p> <p>$2x_1 + 4x_3 \geq 2$</p> <p>$x_1 + 2x_2 \geq 5$</p> <p>$x_1, x_2, x_3 \geq 0$</p> <p>[Ans: $x_1 = 1, x_2 = 2, x_3 = 0, z_{\min} = 1350$]</p>	<p>42</p> <p><i>Maximise</i> $z = 2x_1 + x_2$</p> <p><i>subject to</i> $2x_1 - x_2 \leq 2$</p> <p>$x_1 + x_2 \leq 4$</p> <p>$x_1 \leq 3$</p> <p>$x_1, x_2 \geq 0$</p> <p>[Ans: $x_1 = 1, x_2 = 2, z_{\max} = 6$]</p>

43	<p><i>Maximise</i> $z = 3x_1 + 2x_2$ <i>subject to</i> $2x_1 + x_2 \leq 5$ $x_1 + x_2 \leq 3$ $x_1, x_2 \geq 0$ [Ans: $x_1 = 2, x_2 = 1, z_{\max} = 8$]</p>	44 <p><i>Minimise</i> $z = 4x_1 + 14x_2 + 3x_3$ <i>subject to</i> $-x_1 + 3x_2 + x_3 \geq 3$ $2x_1 + 2x_2 - x_3 \geq 2$ $x_1, x_2, x_3 \geq 0$ [Ans: $x_1 = 0, x_2 = 1, x_3 = 0, z_{\min} = 14$]</p>
45	<p><i>Maximise</i> $z = 5x_1 - 2x_2 + 3x_3$ <i>subject to</i> $2x_1 + 2x_2 - x_3 \geq 2$ $3x_1 - 4x_2 \leq 3$ $x_2 + 3x_3 \leq 5$ $x_1, x_2, x_3 \geq 0$ [Ans: $x_1 = 23/3, x_2 = 5, x_3 = 0, z_{\max} = 85/3$</p>	46 <p><i>Minimise</i> $z = 2x_1 + 2x_2$ <i>subject to</i> $2x_1 + 4x_2 \geq 1$ $x_1 + 2x_2 \geq 1$ $x_1, x_2 \geq 0$ [Ans: $x_1 = 1/3, x_2 = 1/3, z_{\min} = 4/3$]</p>
Using Dual simplex method Solve the following linear programming problem		
47	<p><i>Minimise</i> $z = 2x_1 + 2x_2 + 4x_3$ <i>subject to</i> $2x_1 + 3x_2 + 5x_3 \geq 2$ $3x_1 + x_2 + 7x_3 \leq 3$ $x_1 + 4x_2 + 6x_3 \leq 5$ $x_1, x_2, x_3 \geq 0$ [Ans: $x_1 = 0, x_2 = 2/3, x_3 = 0, z_{\min} = 4/3$</p>	48 <p><i>Maximise</i> $z = -3x_1 - 2x_2$ <i>subject to</i> $x_1 + x_2 \geq 1$ $x_1 + x_2 \leq 7$ $x_1 + 2x_2 \geq 10$ $x_2 \leq 3$ $x_1, x_2 \geq 0$ [Ans: $x_1 = 4, x_2 = 3, z_{\max} = -18$</p>
49	<p><i>Minimise</i> $z = 6x_1 + 3x_2 + 4x_3$ <i>subject to</i> $x_1 + 6x_2 + x_3 = 10$ $2x_1 + 3x_2 + x_3 = 15$ $x_1, x_2, x_3 \geq 0$ [Ans: $x_1 = 20/3, x_2 = 5/9, x_3 = 0, z_{\min} = 125/3$</p>	50 <p><i>Minimise</i> $z = 6x_1 + x_2$ <i>subject to</i> $2x_1 + x_2 \geq 3$ $x_1 - x_2 \geq 0$ $x_1, x_2 \geq 0$ [Ans: $x_1 = 1, x_2 = 1, z_{\min} = 7$]</p>
52	<p><i>Minimise</i> $z = 2x_1 + x_2$ <i>subject to</i> $3x_1 + x_2 \geq 3$ $4x_1 + 3x_2 \geq 6$ $x_1 + 2x_2 \leq 3$ $x_1, x_2 \geq 0$</p>	53

	<p>[Ans: $x_1 = 3/5, x_2 = 6/5, x_3 = 0, z_{\min} = 12/5$</p>	<p><i>Minimise</i> $z = 6x_1 + 7x_2 + 3x_3 + 5x_4$ <i>subject to</i> $2x_1 + 5x_2 + x_3 + x_4 \geq 8$ $x_2 + 5x_3 - 6x_4 \geq 10$ $5x_1 + 6x_2 - 3x_3 + 4x_4 \geq 12$ $x_1, x_2, x_3, x_4 \geq 0$</p> <p>[Ans: $x_1 = 0, x_2 = 30/11, x_3 = 16/11, x_4 = 0$ $z_{\min} = 258/11$]</p>
54	<p><i>Minimise</i> $z = 3x_1 + 2x_2 + x_3 + 4x_4$ <i>subject to</i> $2x_1 + 4x_2 + 5x_3 + x_4 \geq 10$ $3x_1 - x_2 + 7x_3 - 2x_4 \geq 2$ $5x_1 + 2x_2 + x_3 + 6x_4 \geq 15$ $x_1, x_2, x_3, x_4 \geq 0$</p>	
Using the method of Lagrange's multipliers, solve the following N.L.P.P.		
	Question	Ans.
55	<p><i>Optimise</i> $z = x_1^2 + x_2^2 + x_3^2 - 10x_1 - 6x_2 - 4x_3$ <i>subject to</i> $x_1 + x_2 + x_3 = 7$ $x_1, x_2, x_3 \geq 0$</p>	<p>[Ans: $x_1 = 4, x_2 = 2, x_3 = 1, z_{\min} = -35$]</p>
56	<p><i>Optimise</i> $z = 2x_1^2 + 2x_2^2 + 2x_3^2 - 24x_1 - 8x_2 - 12x_3 + 260$ <i>subject to</i> $x_1 + x_2 + x_3 = 11$ $x_1, x_2, x_3 \geq 0$</p>	<p>[Ans: $x_1 = 6, x_2 = 2, x_3 = 3, z_{\min} = 162$]</p>
57	<p><i>Optimise</i> $z = 2x_1^2 + x_2^2 + 3x_3^2 + 10x_1 + 8x_2 + 6x_3 - 100$ <i>subject to</i> $x_1 + x_2 + x_3 = 20$ $x_1, x_2, x_3 \geq 0$</p>	<p>[Ans: $x_1 = 5, x_2 = 11, x_3 = 4, z_{\min} = 281$]</p> <p>(M.U. 2004, 06,13)</p>

58	<p><i>Optimise</i> $z = 12x_1 + 8x_2 + 6x_3 - x_1^2 - x_2^2 - x_3^2 - 23$</p> <p><i>subject to</i> $x_1 + x_2 + x_3 = 10$</p> <p>$x_1, x_2, x_3 \geq 0$</p>	[Ans: $x_1 = 5, x_2 = 3, x_3 = 2, z_{\max} = 35]$
59	<p><i>Maximise</i> $z = 6x_1 + 8x_2 - x_1^2 - x_2^2$</p> <p><i>subject to</i> $4x_1 + 3x_2 = 16$</p> <p>$3x_1 + 5x_2 = 15$</p> <p>$x_1, x_2 \geq 0$</p>	[Ans: $x_1 = 35/11, x_2 = 12/11, z_{\max} = 16.50$])
60	<p><i>Optimise</i> $z = 4x_1^2 + 2x_2^2 + x_3^2 - 4x_1x_2$</p> <p><i>subject to</i> $x_1 + x_2 + x_3 = 15$</p> <p>$2x_1 - 5x_2 + 2x_3 = 20$</p> <p>$x_1, x_2, x_3 \geq 0$</p>	[Ans: $x_1 = 33/9, x_2 = 10/9, x_3 = 8$ $\lambda_1 = 40/9, \lambda_2 = 52/9, z_{\min} = 820/9]$
61	<p><i>Optimise</i> $z = x_1^2 + x_2^2 + x_3^2$</p> <p><i>subject to</i> $x_1 + x_2 + 3x_3 = 2$</p> <p>$5x_1 + 2x_2 + x_3 = 5$</p> <p>$x_1, x_2, x_3 \geq 0$</p>	[Ans: $x_1 = 37/46, x_2 = 16/46, x_3 = 13/46$ $\lambda_1 = 2/23, \lambda_2 = 7/23, z_{\min} = 0.8476$
62	<p><i>Optimise</i> $z = 2x_1^2 + 3x_2^2 + x_3^2$</p> <p><i>subject to</i> $x_1 + x_2 + 2x_3 = 13$</p> <p>$2x_1 + x_2 + x_3 = 10$</p> <p>$x_1, x_2, x_3 \geq 0$</p>	[Ans: $x_1 = 2, x_2 = 1, x_3 = 5, \lambda_1 = 4, \lambda_2 = 2$ $z_{\min} = 36]$
63	<p><i>Optimise</i> $z = 4x_1^2 - x_2^2 - x_3^2 - 4x_1x_2$</p> <p><i>subject to</i> $x_1 + x_2 + x_3 = 15$</p> <p>$2x_1 - x_2 + 2x_3 = 20$</p> <p>$x_1, x_2, x_3 \geq 0$</p>	[Ans: $x_1 = 5095, x_2 = 3033, x_3 = 5.71$ $z_{\min} = 83.87]$
Using the Kuhn-Tucker conditions to solve the following N.L.P.P.		
64	<p><i>Maximise</i> $z = 2x_1^2 - 7x_2^2 + 12x_1x_2$</p> <p><i>subject to</i> $2x_1 + 5x_2 \leq 98$</p> <p>$x_1, x_2 \geq 0$</p>	[Ans: $x_1 = 44, x_2 = 2, z_{\max} = 4900]$

65	<p><i>Maximise</i> $z = 8x_1 + 10x_2 - x_1^2 - x_2^2$</p> <p><i>subject to</i> $3x_1 + 2x_2 \leq 6$</p> <p>$x_1, x_2 \geq 0$</p>	[Ans: $x_1 = 4/13, x_2 = 33/13, z_{\max} = 21.3$]
66	<p><i>Maximise</i> $z = 2x_1 + x_2 - x_1^2$</p> <p><i>subject to</i> $2x_1 + 3x_2 \leq 6$</p> <p>$2x_1 + x_2 \leq 4$</p> <p>$x_1, x_2 \geq 0$</p>	[Ans: $x_1 = 2/3, x_2 = 14/9, z_{\max} = 22/9$]
67	<p><i>Maximise</i> $z = 2x_1 + 3x_2 - x_1^2 - 2x_2^2$</p> <p><i>subject to</i> $2x_1 + 3x_2 \leq 6$</p> <p>$5x_1 + 2x_2 \leq 10$</p> <p>$x_1, x_2 \geq 0$</p>	[Ans: $x_1 =$, $x_2 =$, $z_{\max} =$]
68	<p><i>Maximise</i> $z = 4x_1 + 6x_2 - x_1^2 - x_2^2 - x_3^2$</p> <p><i>subject to</i> $x_1 + x_2 \leq 2$</p> <p>$2x_1 + 3x_2 \leq 12$</p> <p>$x_1, x_2, x_3 \geq 0$</p>	[Ans: $x_1 = 1/2, x_2 = 3/2, x_3 = 0, z_{\max} = 17/2$]
69	<p><i>Maximise</i> $z = 2x_1 + 3x_2 - x_1^2 - x_2^2$</p> <p><i>subject to</i> $x_1 + x_2 \leq 1$</p> <p>$2x_1 + 3x_2 \leq 6$</p> <p>$x_1, x_2 \geq 0$</p>	[Ans: $x_1 = 1/4, x_2 = 3/4, \lambda_1 = 3/2, \lambda_2 = 0$ $z_{\max} = 17/8$]
70	<p><i>Minimise</i> $z = 7x_1^2 + 5x_2^2 - 6x_1$</p> <p><i>subject to</i> $x_1 + 2x_2 \leq 10$</p> <p>$x_1 + 3x_2 \leq 9$</p> <p>$x_1, x_2 \geq 0$</p>	[Ans:
solve the following N.L.P.P.		
71	<p>Find the relative maximum or minimum of the function</p> <p>$z = x_1^2 + x_2^2 + x_3^2 - 6x_1 - 10x_2 - 14x_3 + 103$</p>	$x_1=3, x_2=5, x_3=7, z_{\max}=20$
72	<p>Find the relative maximum or minimum of the function</p> <p>$z = x_1^2 + x_2^2 + x_3^2 - 8x_1 - 10x_2 - 12x_3 + 100$</p>	$x_1=4, x_2=5, x_3=6, z_{\max}=23$
73	<p>Obtain the relative maximum or minimum, if any, of the function</p> <p>$z = 2x_1 + 6x_3 + 9x_2x_3 - 4x_1^2 - 9x_2^2 - 9x_3^2$</p>	$x_1=1/4, x_2=2/9, x_3=4/9, z_{\max}=19/12$
74	<p>Obtain the relative maximum or minimum, if any, of the function</p> <p>$z = 2x_1 + x_3 + 3x_2x_3 - x_1^2 - 3x_2^2 - 3x_3^2 + 17$</p>	$x_1=1, x_2=1/9, x_3=2/9, z_{\max}=18$