`si`	assumed value of the angle ψ (degrees)
`dell`	assumed value of the angle δ_1 (degrees

The output variables are

`g, a, e, h, c, f`	distances or lengths of the links in mm

Example 5.13 ***Design a four-link mechanism to guide a rigid body through three finitely separated positions given by***

$\beta_1 = 105°$	$r_1 = 80$ *mm*	$\alpha_1 = 65°$
$\beta_2 = 95°$	$r_2 = 90$ *mm*	$\alpha_2 = 56°$
$\beta_3 = 85°$	$r_3 = 96$ *mm*	$\alpha_3 = 48°$

Assume the values of γ, ψ ***and*** δ_1 ***as*** *20°, 10°* ***and*** *150°* ***respectively.***

Solution: Figure 5.44 shows the input and the four sets of values of the output obtained by using the program of Fig. 5.43.

```
Enter values of tb1, tb2, tb3, r1, r2, r3, al1, al2, al3, gamm, si, dell
105  95  85  80  90  96  65  56  48  20 10  150
     g            e            a            h            c            f
   27.04       102.24        49.76        32.33       240.67      -201.61
   27.04       102.24        49.76        81.82        27.25        66.79
   53.75        40.60        16.14        32.33       240.67      -201.61
   53.75        40.60        16.14        81.82        27.25        66.79
```

Fig. 5.44

Summary

1. Dimensional synthesis of a pre-conceived type mechanism seeks to determine the principal dimensions of various links that satisfy the requirements of motion of the mechanism.
2. *Function generation* involves correlating the rotary or the sliding motion of the input and the output links. The motion of the output and the input links may be prescribed by an arbitrary function $y = f(x)$.
3. When a point on the coupler or the floating link of a mechanism is to be guided along a prescribed path, it is said to be a *path-generation* problem. This guidance of the path of the point may or may not be coordinated with the movement of the input link.
4. *In motion generation*, a mechanism is designed to guide a rigid body in a prescribed path.
5. A *pole* of a moving link is the centre of its rotation with respect to a fixed link.
6. If the rotation of the link is considered relative to another moving link, the pole is known as the *relative pole*.
7. The problems of function generation for two and three accuracy positions are easily solved by the relative pole method.
8. In the inversion method, there is direct use of the concept of inversion.
9. *Freudenstein's* equation is
$$\frac{d}{a}\cos\varphi - \frac{d}{c}\cos\theta + \frac{a^2 - b^2 + c^2 + d^2}{2ac} = \cos(\theta - \varphi) = \cos(\varphi - \theta)$$
and is used to coordinate positions of the input and output links of the four-link mechanism.
10. For n accuracy positions in the range $x_0 \le x \le x_{n+1}$, the Chebychev spacing is given by
$$x_i = \frac{x_{n+1} + x_0}{2} - \frac{x_{n+1} - x_0}{2}\cos\frac{(2i-1)\pi}{2n}$$
where i = 1, 2, 3 ....n

Exercises

1. What do you mean by dimensional synthesis of a pre-conceived type mechanism?
2. Explain the terms: function generation, path generation and motion generation.

3. What is the pole of a coupler link of four-link mechanism? Enumerate its properties. What is a relative pole?
4. Describe the procedure to design a four-link mechanism by relative pole method when three positions of the input (θ_1, θ_2, θ_3) and the output link (φ_1, φ_2, φ_3) are known.
5. Describe the procedure to design a slider-crank mechanism by relative pole method when three positions of the input link (θ_1, θ_2, θ_3) and the slider (s_1, s_2, s_3) are known.
6. Discuss the procedure to design the mechanisms by inversion method.
7. What is *Freudenstein's* equation? How is it helpful in designing a four-link mechanism when three positions of the input (θ_1, θ_2, θ_3) and the output link (φ_1, φ_2, φ_3) are known?
8. What is least-square technique? When is it useful in designing a four-link mechanism?
9. What do you mean by *precision* or *accuracy* points in the design of mechanisms? What is *structural error?*
10. What is *Chebychev spacing*? What is its significance?
11. Design a four-link mechanism to coordinate three positions of the input and the output links for the following angular displacements using relative pole method:
    $\theta_{12} = 50°$ $\varphi_{12} = 40°$
    $\theta_{13} = 70°$ $\varphi_{13} = 75°$
12. Design a slider-crank mechanism to coordinate three positions of the input link and the slider for the following angular and linear displacements of the input link and the slider respectively:
    $\theta_{12} = 30°$ $s_{12} = 100$ mm
    $\theta_{13} = 90°$ $s_{13} = 200$ mm
    Take eccentricity of the slider as 10 mm. Use the relative pole method.
13. In a four-link mechanism, the angular displacements of the input link are 30° and 75° and of the output link, 40° and 65° respectively. Design the mechanism using the inversion method.
14. Design a slider-crank mechanism to coordinate three positions of the input and of the slider when the angular displacements of the input link are 40° and 75° and linear displacements of the slider are 55 mm and 90 mm respectively with an eccentricity of 20 mm. Use the inversion method.
15. For the following angular displacements of the input and the output links, design a four-link mechanism:
    $\theta_{12} = 40°$ $\varphi_{12} = 45°$
    $\theta_{13} = 85°$ $\varphi_{13} = 75°$
    $\theta_{13} = 120°$ $\varphi_{13} = 110°$
16. Design a four-link mechanism that coordinates the following three positions of the coupler point if the positions are indicated with respect to coordinate axes:
    $r_1 = 60$ mm $\alpha_1 = 75°$
    $r_2 = 75$ mm $\alpha_2 = 60°$
    $r_3 = 85$ mm $\alpha_3 = 50°$
    The angular displacements of the input link are $\theta_{12} = 40°$ and $\theta_{13} = 75°$.
17. Design a four-link mechanism to coordinate three positions of the input and the output links given by
    $\theta_1 = 25°$ $\varphi_1 = 30°$
    $\theta_2 = 35°$ $\varphi_2 = 40°$
    $\theta_3 = 50°$ $\varphi_3 = 60°$ (5.6, 0.17, 4.88, 1)
18. Design a four-link mechanism when the motions of the input and the output links are governed by the function $y = 2x^2$ and x varies from 2 to 4 with an interval of 1. Assume θ to vary from 40° to 120° and ϕ from 60° to 132°. (1.73, 0.70, 1.78, 1.00)
19. Design a four-link mechanism to coordinate the motions of the input and the output links governed by a function $y = 2 \log x$ for $2 < x < 12$. Take $\Delta x = 1$. Assume suitable ranges for θ and φ.
20. Design a four-link mechanism if the motions of the input and the output links are governed by a function $y = x^{1.5}$ and x varies from 1 to 4. Assume θ to vary from 30° to 120° and φ from 60° to 130°. The length of the fixed link is 30 mm. Use Chebychev spacing of accuracy points.
21. Design a four-link mechanism to guide a rigid body through three positions of the input link with three positions of the coupler point, the data for which is given below:

$\theta_1 = 40°$	$r_1 = 90$ mm	$\alpha_1 = 78°$
$\theta_2 = 55°$	$r_2 = 40$ mm	$\alpha_2 = 90°$
$\theta_3 = 70°$	$r_3 = 75$ mm	$\alpha_3 = 95°$

22. Design a four-link mechanism, the coupler point of which traces a coupler curve that is approximated by ten positions given by the following data

$\theta_1 = 160°$	$r_1 = 57$ mm	$\alpha_1 = 70°$
$\theta_2 = 130°$	$r_2 = 76$ mm	$\alpha_2 = 65°$
$\theta_3 = 98°$	$r_3 = 88$ mm	$\alpha_3 = 55°$
$\theta_4 = 73°$	$r_4 = 98$ mm	$\alpha_4 = 45°$
$\theta_5 = 32°$	$r_5 = 92$ mm	$\alpha_5 = 30°$
$\theta_6 = -15°$	$r_6 = 89$ mm	$\alpha_6 = 20°$
$\theta_7 = -25°$	$r_7 = 82$ mm	$\alpha_7 = 19°$
$\theta_8 = -70°$	$r_8 = 53$ mm	$\alpha_8 = 25°$
$\theta_9 = -125°$	$r_9 = 38$ mm	$\alpha_9 = 50°$
$\theta_{10} = -165°$	$r_{10} = 42$ mm	$\alpha_{10} = 70°$