

Chapter 7

Problems

7.1 Problem Set: Mechanisms

The dimensions of the planar mechanisms, shown in Figs. 7.1-7.15, are given in Tables 7.1-7.15, respectively. The angle of the driver link 1 with the horizontal axis is ϕ . The constant angular speed of the driver link 1 is n and is given in the tables.

1. Determine the type of motion (rotation, translation, and complex motion) for each link, the connectivity table, the structural diagram, the contour diagram, the independent contours, the number of degrees of freedom, the dyads, and the type of the dyads.
2. Find the positions of the joints and the angles of the links with the horizontal axis when the angle of the driver link 1 with the horizontal axis is ϕ . Write a MATLAB[®] program for the positions of the mechanism for the given angle ϕ .
3. Write a MATLAB program for the positions of the mechanism for a complete rotation of the driver link 1, $\phi \in [0^\circ, \dots, 360^\circ]$, using different methods.
4. Write a MATLAB program for the path of a point on a link with general plane motion.
5. Write a MATLAB program for the animation (movie) of the mechanism for a complete rotation of the driver link 1, $\phi \in [0^\circ, \dots, 360^\circ]$.
6. Find the velocities and the accelerations of the mechanism, using different methods, for the given position when the driver link 1 makes an angle ϕ with the horizontal axis, The constant angular speed of the driver link 1 is n . Write a MATLAB program.
7. The link bars of the mechanism are homogeneous rectangular prisms with the width $h = 0.01$ m and the depth $d = 0.001$ m. The sliders have the width $w_{Slider} = 0.050$ m, the height $h_{Slider} = 0.020$ m, and the same depth $d = 0.001$ m. The links of the mechanism are homogeneous made of steel having a mass density $\rho_{Steel} = 8000$ kg/m³. The gravitational acceleration is $g = 9.807$ m/s². The driver link 1 has a constant angular speed n . The external force or moment applied on the last link 5 is opposed to the motion of the link and has the value: $|\mathbf{F}_{5ext}| = 2000$ N if

the last link 5 has a translational motion or, $|\mathbf{M}_{5ext}| = 3000 \text{ N}\cdot\text{m}$ if the last link 5 has a rotational motion.

Determine the joint forces and the motor moment \mathbf{M}_m required for the dynamic equilibrium of the considered mechanism when the the driver link 1 makes an angle ϕ with the horizontal axis. Write MATLAB programs for different methods of calculating the dynamical forces.

Table 7.1 Mechanism 1

No	AB [m]	AD [m]	BC [m]	CD [m]	ϕ [°]	n [rpm]
1	0.08	0.19	0.21	0.12	60°	500
2	0.10	0.24	0.26	0.14	120°	600
3	0.18	0.43	0.47	0.27	210°	700
4	0.15	0.36	0.40	0.21	330°	800

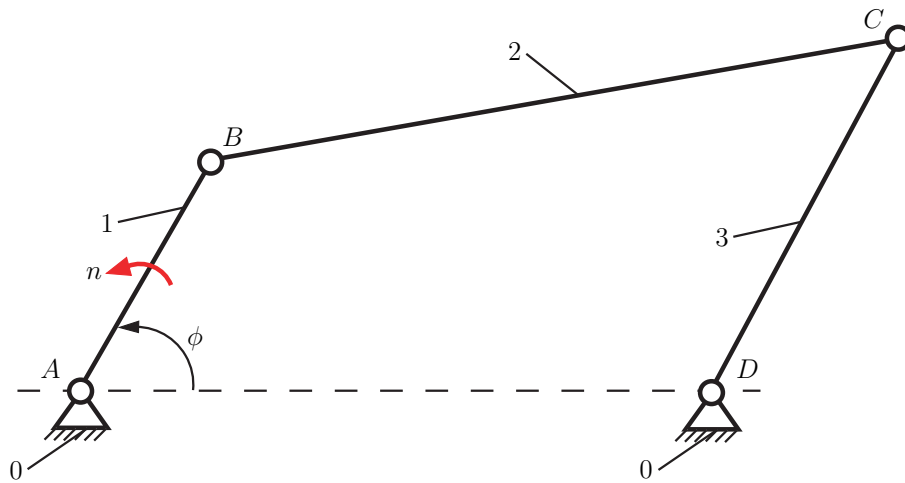


Fig. 7.1 Mechanism 1

Table 7.2 Mechanism 2

No	AB [m]	BC [m]	CD [m]	CE [m]	EF [m]	a [m]	b [m]	c [m]	ϕ [°]	n [rpm]
1	0.15	0.40	0.37	0.23	0.23	0.30	0.45	0.37	330°	500
2	0.10	0.27	0.25	0.15	0.15	0.20	0.30	0.25	120°	800
3	0.12	0.32	0.30	0.18	0.18	0.24	0.36	0.30	240°	900
4	0.20	0.55	0.50	0.30	0.30	0.40	0.60	0.50	300°	1000

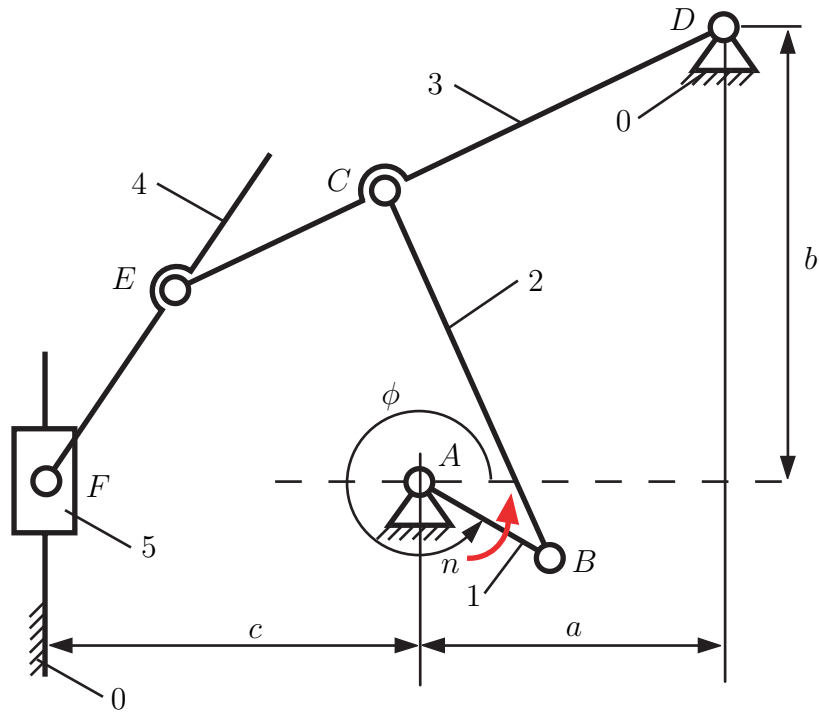


Fig. 7.2 Mechanism 2

Table 7.3 Mechanism 3

No	AB [m]	BC [m]	CD [m]	DE [m]	EF [m]	a [m]	b [m]	ϕ [°]	n [rpm]
1	0.02	0.03	0.03	0.03	0.06	0.03	0.01	30°	600
2	0.05	0.20	0.20	0.31	0.30	0.10	0.06	150°	700
3	0.09	0.11	0.07	0.11	0.12	0.035	0.025	240°	900
4	0.22	0.27	0.17	0.25	0.28	0.09	0.055	330°	1100

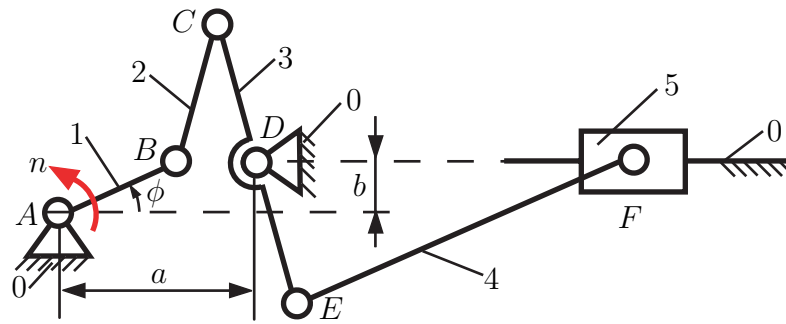
**Fig. 7.3** Mechanism 3

Table 7.4 Mechanism 4

No	AB [m]	BC [m]	CE [m]	CD [m]	EF [m]	a [m]	b [m]	c [m]	ϕ [°]	n [rpm]
1	0.09	0.40	0.25	0.12	0.21	0.22	0.35	0.40	60°	400
2	0.15	0.67	0.45	0.22	0.32	0.33	0.60	0.65	135°	600
3	0.22	1.00	0.65	0.35	0.60	0.55	0.90	1.20	240°	800
4	0.16	0.70	0.50	0.25	0.48	0.40	0.60	0.70	300°	1000

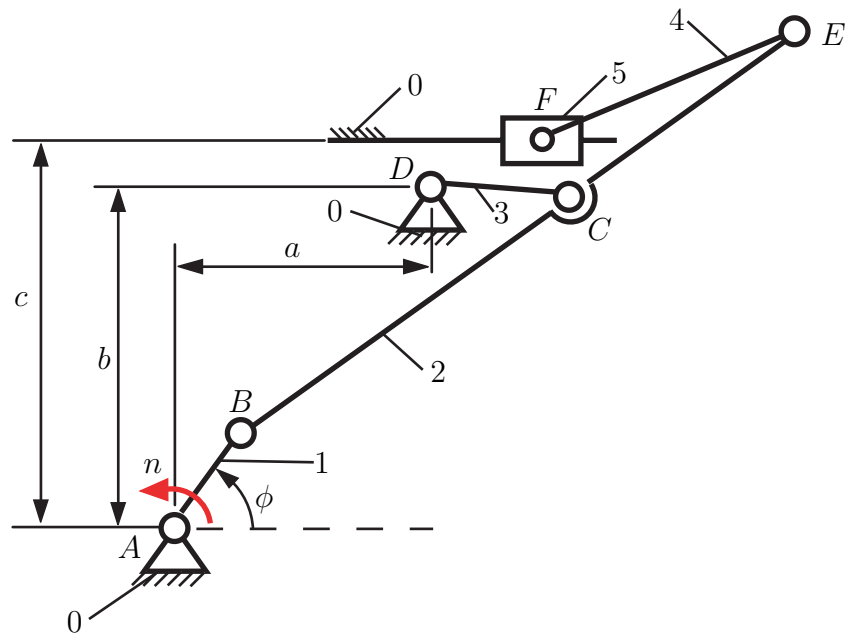


Fig. 7.4 Mechanism 4

Table 7.5 Mechanism 5

No	AB [m]	BC [m]	CD [m]	CE [m]	EF [m]	a [m]	b [m]	c [m]	ϕ [°]	n [rpm]
1	0.10	0.37	0.15	0.15	0.25	0.12	0.36	0.09	45°	1000
2	0.08	0.30	0.12	0.12	0.20	0.10	0.30	0.08	135°	1100
3	0.12	0.45	0.18	0.18	0.30	0.15	0.45	0.14	225°	1200
4	0.06	0.24	0.09	0.09	0.18	0.075	0.225	0.070	315°	1300

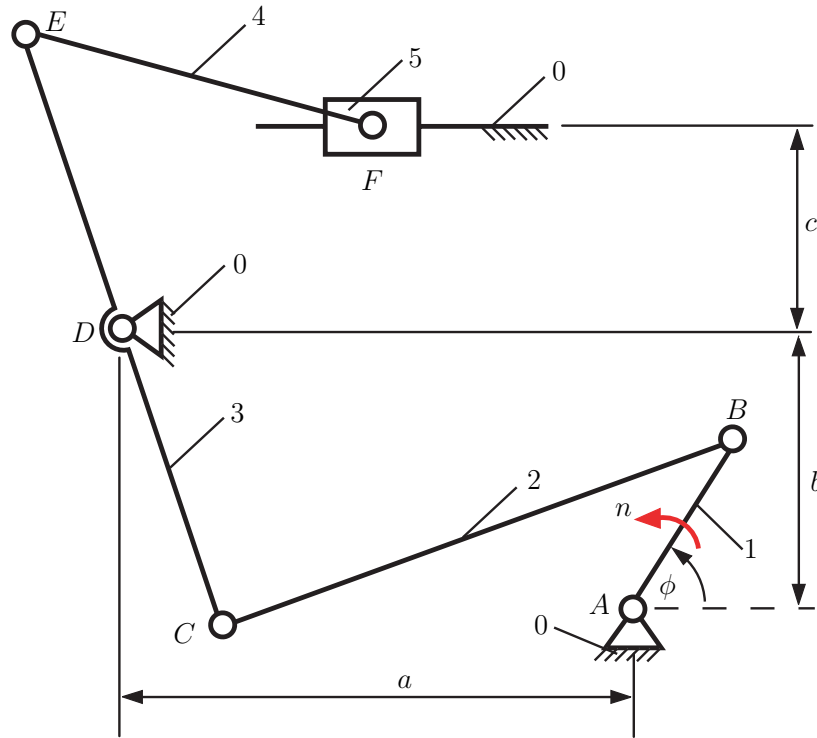
**Fig. 7.5** Mechanism 5

Table 7.6 Mechanism 6

No	AB [m]	AC [m]	BD [m]	DE [m]	EF [m]	a [m]	b [m]	ϕ [°]	n [rpm]
1	0.06	0.18	0.27	0.12	0.08	0.02	0.01	225°	600
2	0.08	0.20	0.30	0.16	0.11	0.025	0.13	45°	750
3	0.05	0.12	0.18	0.10	0.065	0.017	0.085	135°	950
4	0.04	0.10	0.16	0.09	0.063	0.013	0.065	315°	1150

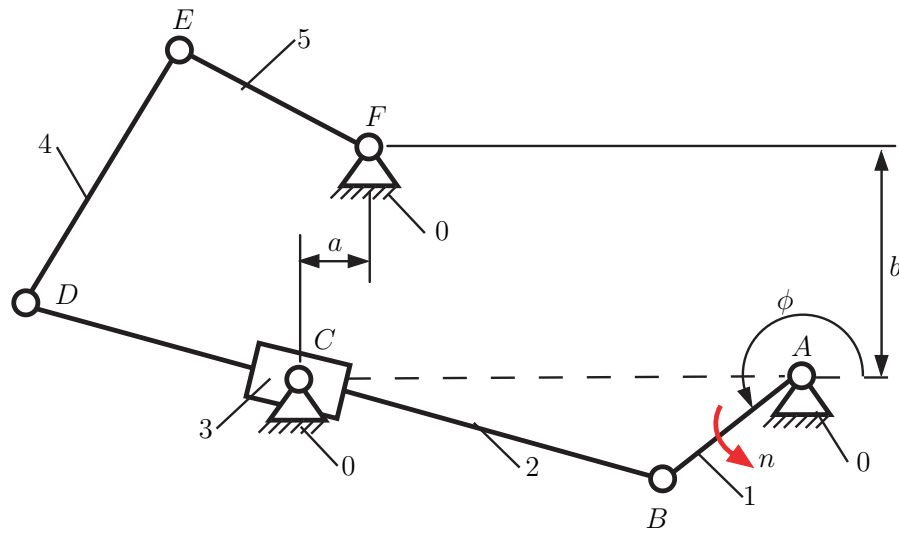
**Fig. 7.6** Mechanism 6

Table 7.7 Mechanism 7

No	AB [m]	AD [m]	BC [m]	a [m]	ϕ [$^\circ$]	n [rpm]
1	0.08	0.20	0.10	0.15	300°	1000
2	0.06	0.15	0.08	0.50	210°	1200
3	0.10	0.25	0.12	0.50	150°	1300
4	0.12	0.30	0.15	0.50	30°	1500

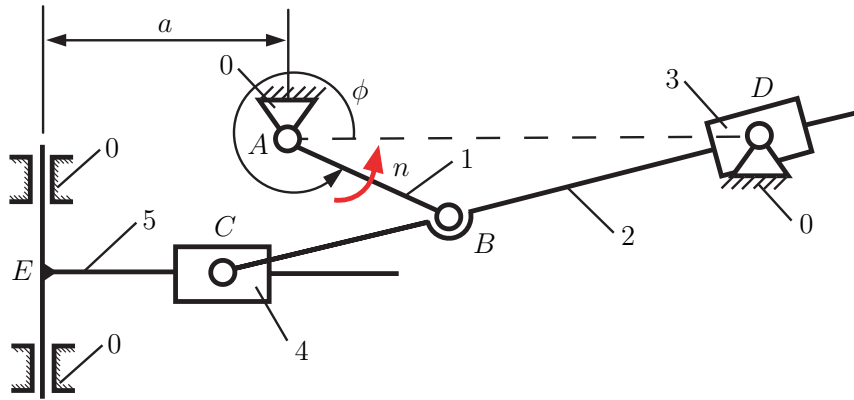
**Fig. 7.7** Mechanism 7

Table 7.8 Mechanism 8

No	AB [m]	AD [m]	BC [m]	CE [m]	EF [m]	a [m]	ϕ [°]	n [rpm]
1	0.22	1.00	0.65	0.18	0.70	0.60	300°	1000
2	0.25	1.10	0.70	0.20	0.80	0.65	120°	1200
3	0.20	1.00	0.55	0.15	0.60	0.52	60°	1500
4	0.18	0.80	0.40	0.10	0.50	0.43	225°	1800

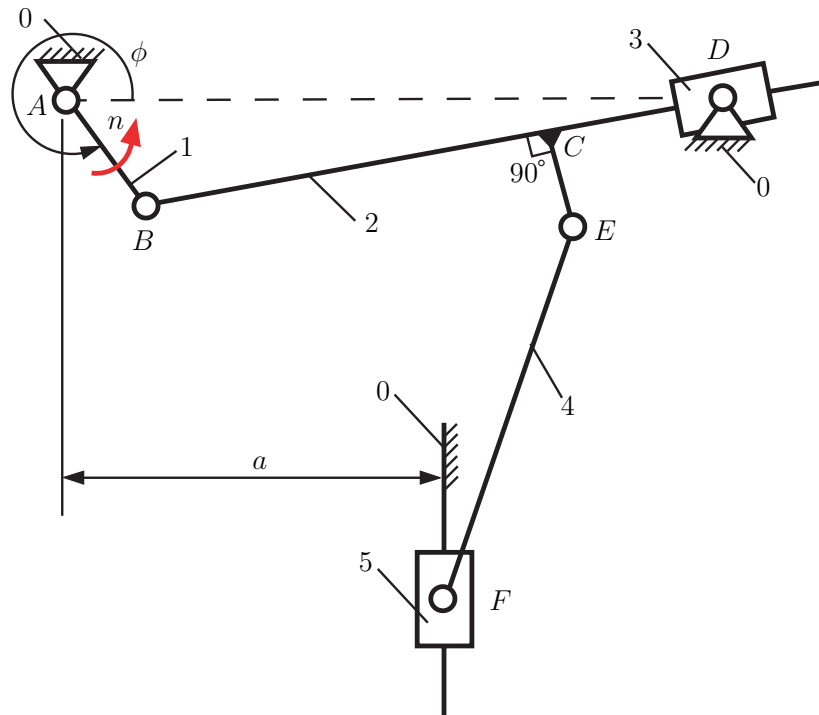
**Fig. 7.8** Mechanism 8

Table 7.9 Mechanism 9

No	AB [m]	AC [m]	CD [m]	DE [m]	ϕ [°]	n [rpm]
1	0.22	0.08	0.20	0.60	240°	500
2	0.18	0.08	0.20	0.50	30°	600
3	0.15	0.05	0.18	0.45	120°	700
4	0.08	0.03	0.07	0.20	330°	800

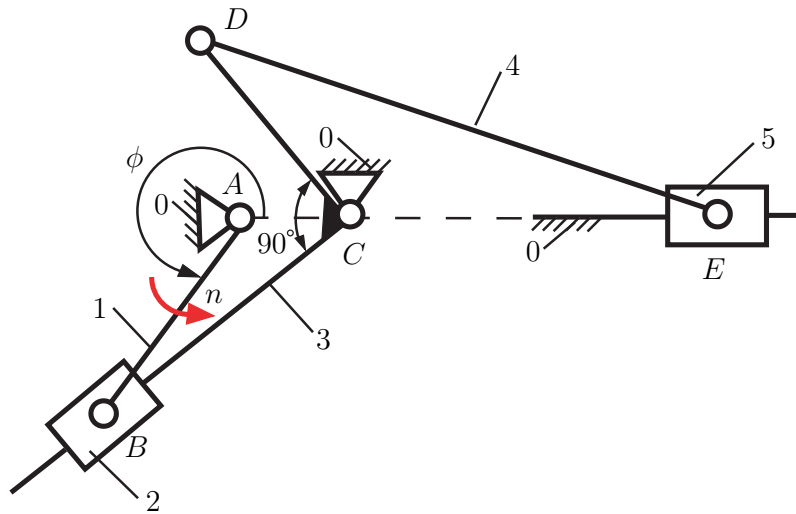
**Fig. 7.9** Mechanism 9

Table 7.10 Mechanism 10

No	AB [m]	AE [m]	BC [m]	CD [m]	a [m]	ϕ [°]	n [rpm]
1	0.03	0.07	0.05	0.08	0.05	30°	400
2	0.10	0.25	0.17	0.30	0.09	120°	600
3	0.12	0.30	0.20	0.35	0.10	200°	800
4	0.09	0.35	0.25	0.40	0.12	300°	1000

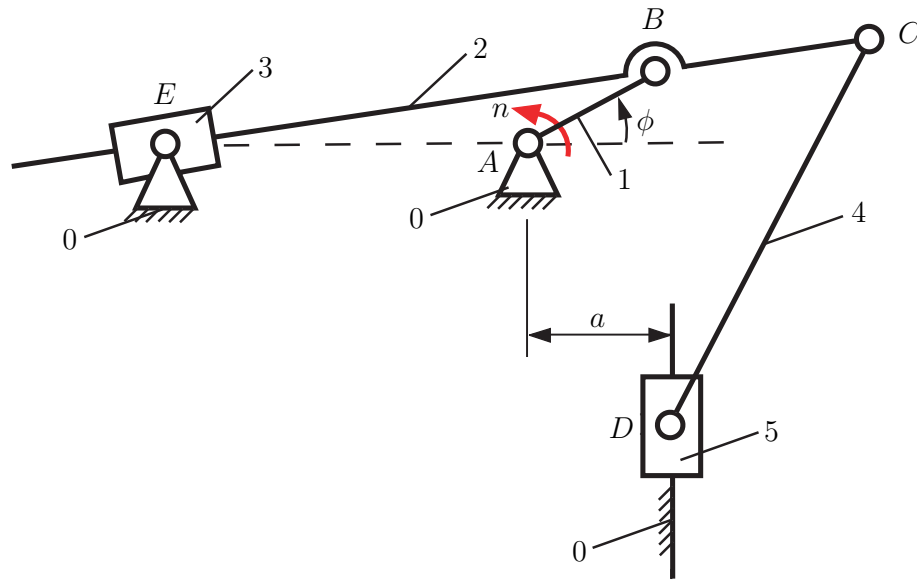
**Fig. 7.10** Mechanism 10

Table 7.11 Mechanism 11

No	AB [m]	CD [m]	DE [m]	AC [m]	ϕ [°]	n [rpm]
1	0.08	0.14	0.40	0.04	45°	300
2	0.10	0.16	0.45	0.03	135°	400
3	0.25	0.40	1.00	0.10	225°	500
4	0.22	0.30	0.90	0.06	315°	600

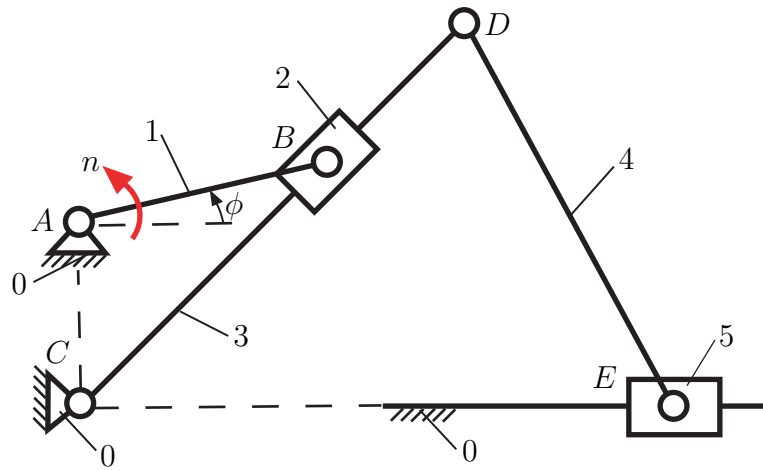
**Fig. 7.11** Mechanism 11

Table 7.12 Mechanism 12

No	AB [m]	AC [m]	BD [m]	a [m]	b [m]	ϕ [$^\circ$]	n [rpm]
1	0.12	0.30	0.50	0.08	0.15	60°	500
2	0.10	0.30	0.50	0.07	0.12	150°	700
3	0.09	0.30	0.45	0.06	0.10	240°	900
4	0.08	0.25	0.40	0.05	0.09	330°	1100

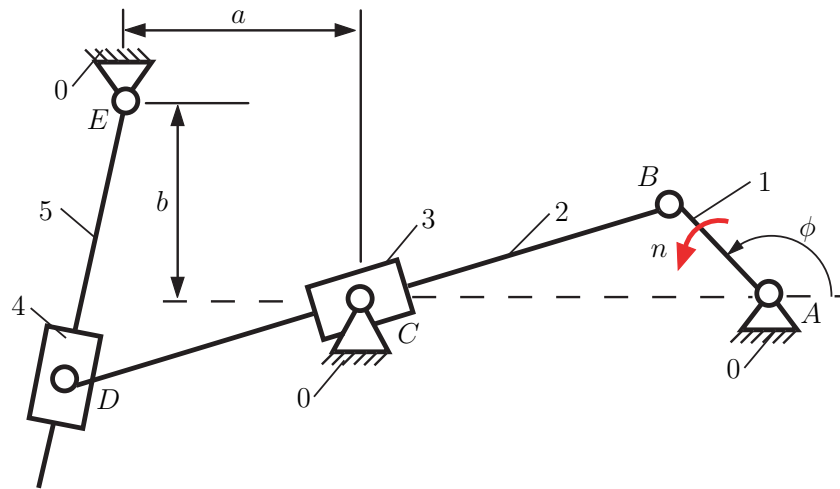
**Fig. 7.12** Mechanism 12

Table 7.13 Mechanism 13

No	AB [m]	BC [m]	CD [m]	a [m]	b [m]	ϕ [°]	n [rpm]
1	0.20	0.21	0.39	0.30	0.25	45°	500
2	0.18	0.17	0.35	0.27	0.26	135°	1000
3	0.10	0.25	0.15	0.225	0.30	240°	1500
4	0.22	0.23	0.45	0.30	0.32	315°	2000

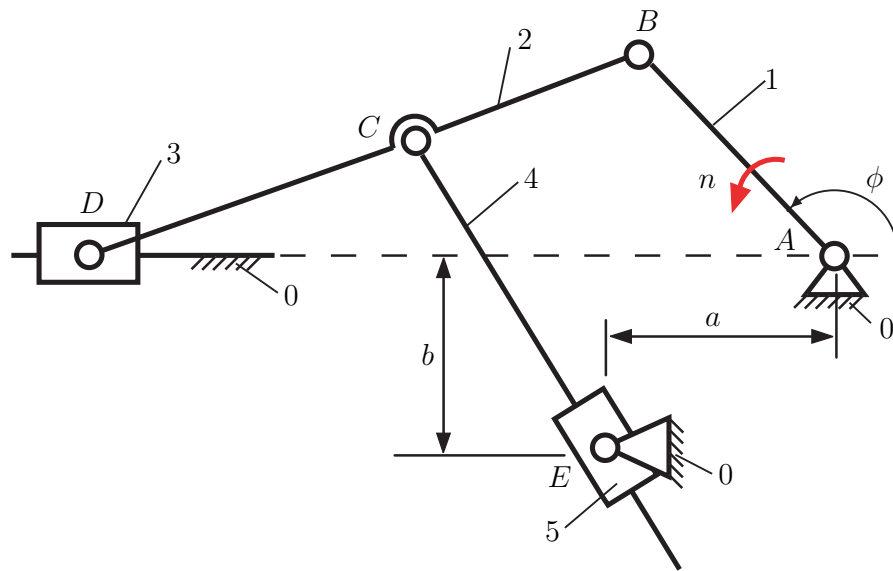
**Fig. 7.13** Mechanism 13

Table 7.14 Mechanism 14

No	AB [m]	AC [m]	CD [m]	DE [m]	a [m]	ϕ [°]	n [rpm]
1	0.10	0.20	0.12	0.08	0.13	20°	500
2	0.08	0.15	0.10	0.10	0.12	110°	600
3	0.15	0.30	0.20	0.14	0.25	200°	700
4	0.07	0.15	0.10	0.06	0.11	290°	800

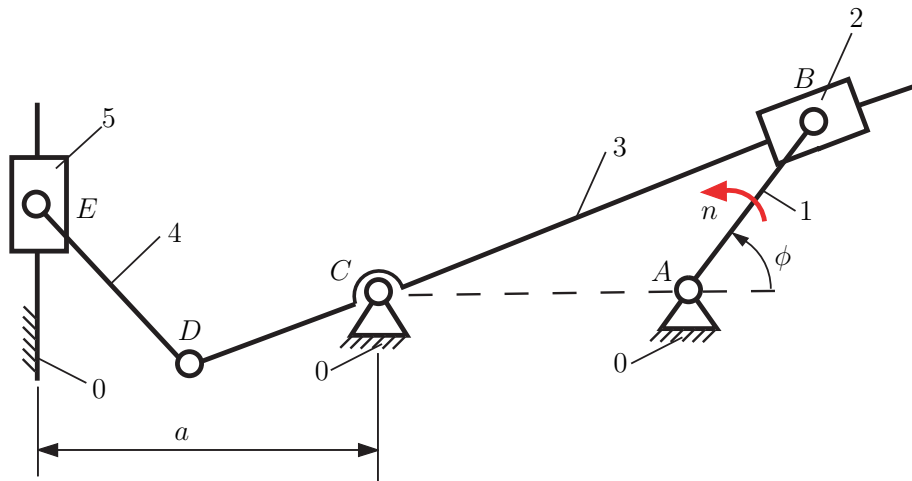
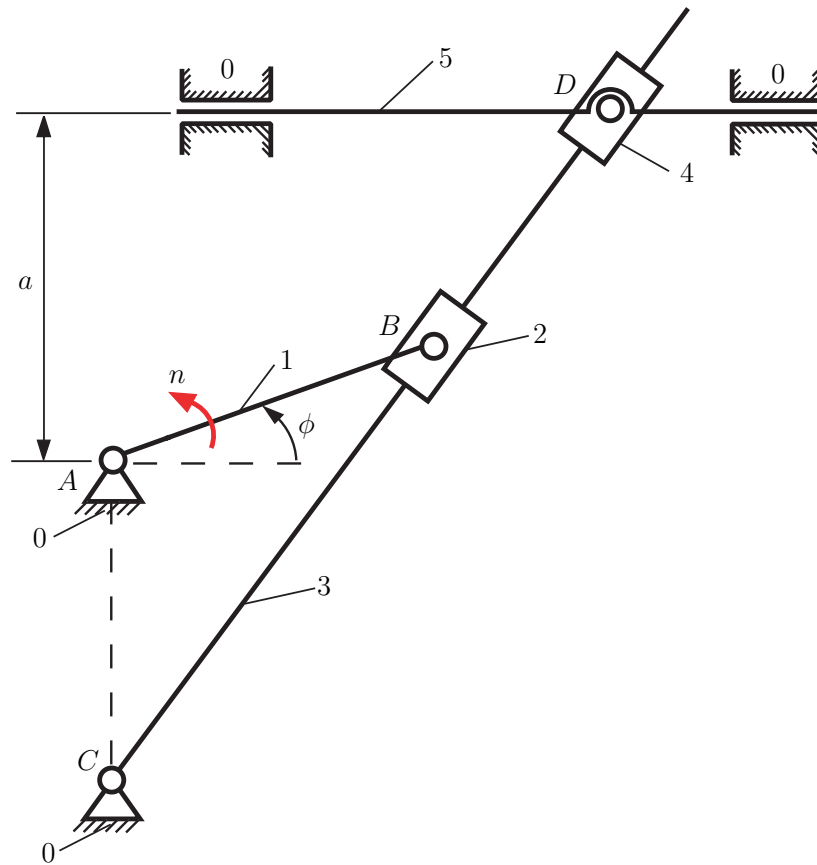
**Fig. 7.14** Mechanism 14

Table 7.15 Mechanism 15

No	AB [m]	AC [m]	a [m]	ϕ [°]	n [rpm]
1	0.04	0.10	0.08	60°	500
2	0.05	0.10	0.07	120°	600
3	0.08	0.10	0.09	210°	700
4	0.08	0.20	0.10	330°	800

**Fig. 7.15** Mechanism 15