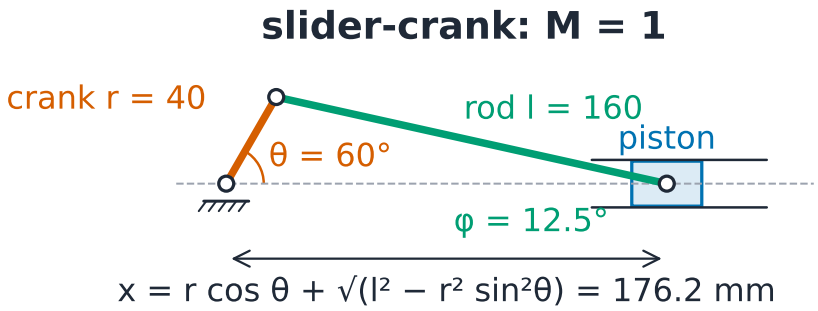
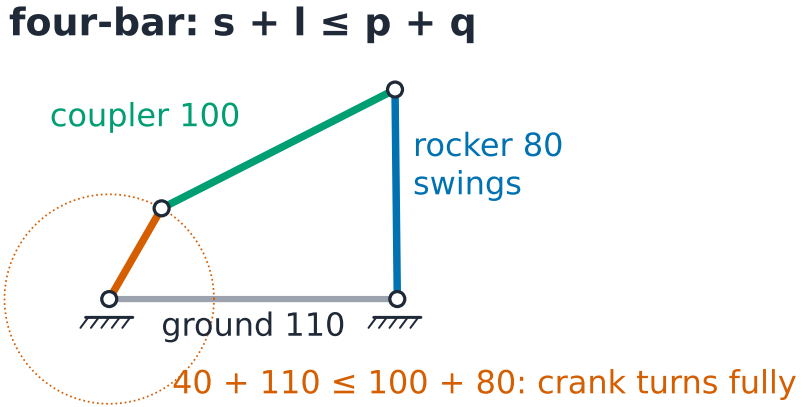
Exercise walk-through

11.1
Mechanisms and kinematic pairs

University Mechanical Engineering

Slider-crank and four-bar





$r = 40$, $l = 160$, $\theta = 60°$: $\phi = \mathbf{12.5}°$, $x = \mathbf{176.2}$ mm, stroke 80 mm; $M = 3(n-1) - 2j_1 = \mathbf{1}$.

Counting and inverting

1. **Four-bar** $40/100/80/110$, $\theta_2 = 60^\circ \to \theta_3 = \mathbf{27.0}^\circ$, $\theta_4 = \mathbf{90.6}^\circ$.
2. **Type** Shortest link as crank $\to$ crank-rocker; ground the coupler $\to$ double-rocker.
3. **Five-bar** 5 **links**, 5 pins $\to$ $M = 3 \times 4 - 2 \times 5 = \mathbf{2}$ inputs.

Decision

Count before you calculate; the count says how many motors you need.

Exercises 2.1·2.2

2.1 A slider-crank has $r = 50$ mm and $l = 200$ mm. At $\theta = 45°$ find the rod angle ϕ (two decimals, degrees) and the piston position x (one decimal, mm). State the stroke. [4]

2.2 Find M for (a) a six-bar chain of 6 links and 7 pins, and (b) a mechanism of 5 links with 5 pins and one cam contact. [3]

Exercises 2.1·2.2

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2.1

- $\sin\phi = r\sin\theta/l = 50\sin 45°/200 = 0.1768$, so $\phi = \mathbf{10.18}°$.
- $x = r\cos\theta + \sqrt{l^2 - r^2\sin^2\theta} = 35.4 + 196.9 = \mathbf{232.2}$ mm.
- Stroke $= 2r = \mathbf{100}$ mm.

2.2 Find M for (a) a six-bar chain of 6 links and 7 pins, and (b) a mechanism of 5 links with 5 pins and one cam contact. [3]

2.2

- (a) $M = 3(n-1) - 2j_1 = 3\times 5 - 2\times 7 = \mathbf{1}$.
- (b) $M = 3(n-1) - 2j_1 - j_2 = 3\times 4 - 2\times 5 - 1 = \mathbf{1}$: the cam is a two-freedom pair, so it removes one.

Exercise 2.3

2.3 A chain has links of 30, 90, 70 and 100 mm. Is it Grashof? Name the mechanism when the 30 mm link is the ground. [3]

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2.3

- $s + l = 30 + 100 = 130 \leq p + q = 90 + 70 = 160$: Grashof.
- With the shortest link fixed, both neighbours turn fully: a **double-crank** (drag link).

Exercise 3.1

3.1 A four-bar has crank 50 mm, coupler 120 mm, rocker 90 mm and ground 130 mm, with the rocker pivot 130 mm to the right of the crank pivot. (a) Show it is a crank-rocker. (b) At $\theta_2 = 90^\circ$ find the distance from the crank pin to the rocker pivot (one decimal, mm), and by the cosine rule the coupler angle θ_3 and rocker angle θ_4 (one decimal, degrees, open assembly). [7]

Exercise 3.1

3.1 A four-bar has crank 50 mm, coupler 120 mm, rocker 90 mm and ground 130 mm, with the rocker pivot 130 mm to the right of the crank pivot. (a) Show it is a crank-rocker. (b) At $\theta_2 = 90°$ find the distance from the crank pin to the rocker pivot (one decimal, mm), and by the cosine rule the coupler angle θ_3 and rocker angle θ_4 (one decimal, degrees, open assembly). [7]

3.1

- (a) $s + l = 50 + 130 = 180 \le 120 + 90 = 210$: Grashof, and the shortest link is the crank, so it is a crank-rocker.
- (b) Crank pin $B = (0, 50)$, rocker pivot $O_4 = (130, 0)$: $BO_4 = \sqrt{130^2 + 50^2} = \mathbf{139.3}$ mm, at $-21.0°$ from B.
- Cosine rule in triangle BCO_4: $\cos\alpha = (b^2 + BO_4^2 - c^2)/(2b\,BO_4) = 0.7688$, so $\alpha = 39.8°$.
- $\theta_3 = -21.0° + 39.8° = \mathbf{18.7}°$.
- $C = B + 120(\cos 18.7°, \sin 18.7°) = (113.7, 88.5)$ mm, so $\theta_4 = \operatorname{atan2}(88.5, 113.7 - 130) = \mathbf{100.5}°$.