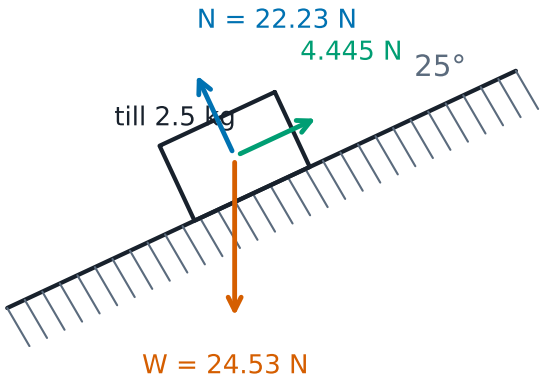
Exercise walk-through

3.5
Rigid-body kinematics

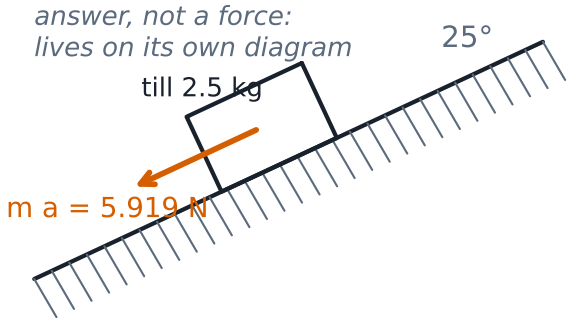
University Mechanical Engineering

Particle kinetics: forces left, answer right

Free-body diagram

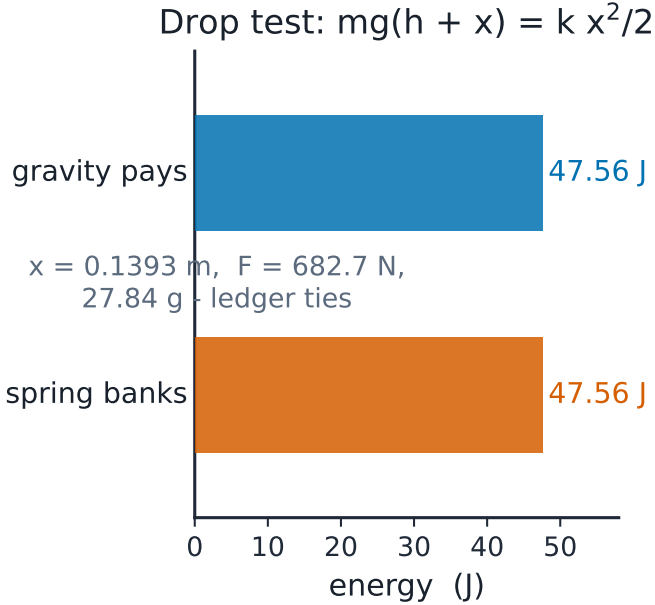


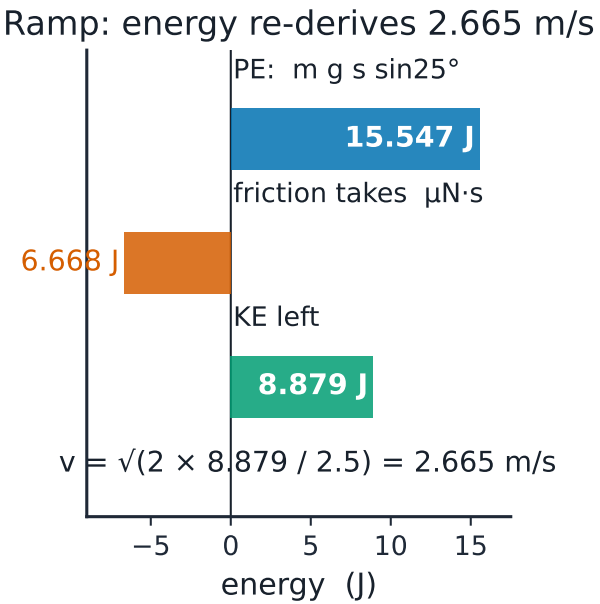
Kinetic diagram



The 25° ramp, $\mu_k = 0.20$: $N = \mathbf{22.23}$ N, **friction** $\mathbf{4.445}$ N, $a = 9.81(\sin 25° - 0.20\cos 25°) = \mathbf{2.368}$ m/s^2, $v = \mathbf{2.665}$ m/s after 1.50 m. Cart slip at $\mu_s g = \mathbf{3.434}$ m/s^2; the turntable needs $\mu \geq \mathbf{0.3058}$.

Work and energy: the ledger must tie

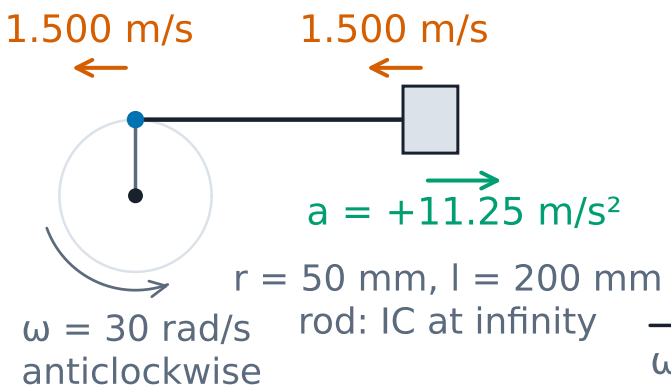




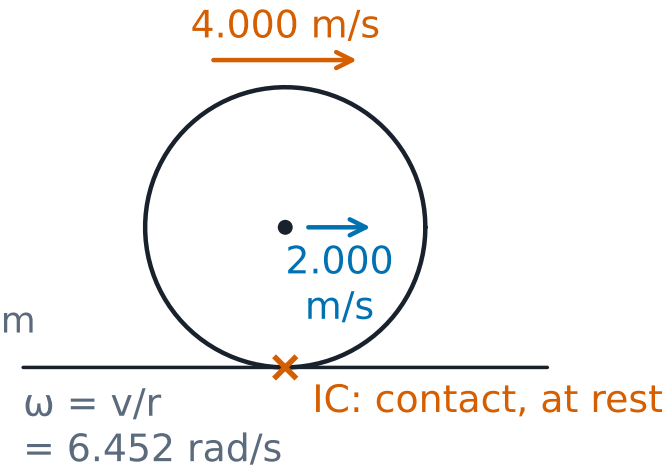
The drop ledger balances at **47.56** J; the ramp re-derives **2.665** m/s.

Rigid-body kinematics: constraint first

Slider-crank at 90°



Rolling wheel



At $\theta = 90°$ the slider moves at $\mathbf{-1.500}$ m/s and accelerates at $\mathbf{+11.25}$ m/s^2.

Exercises 2.1·2.2

2.1 The piston position at quarter-turn (four decimals), and its velocity magnitude there (three decimals). [3]

2.2 The table acceleration at quarter-turn and at dead centre (two decimals), and the ratio between the extremes. [4]

Exercises 2.1·2.2

2.1 The piston position at quarter-turn (four decimals), and its velocity magnitude there (three decimals). [3]

2.1

- $x = \sqrt{l^2 - r^2} = \sqrt{0.160^2 - 0.040^2} = 0.1549$ m.
- $|\dot{x}| = r\omega = 1.000$ m/s.

2.2 The table acceleration at quarter-turn and at dead centre (two decimals), and the ratio between the extremes. [4]

2.2

- Quarter-turn: $\ddot{x} = r\omega^2\lambda = 0.040 \times 625 \times 0.25 = 6.25$ m/s^2.
- Dead centre: $-r\omega^2(1+\lambda) = -31.25$ m/s^2.
- Ratio 5:1 - the fatigue file's range.

Exercises 2.3·2.4

2.3 A 0.250 m wheel rolls without slipping at 1.80 m/s: the angular velocity (rad/s, one decimal), and the speeds of the contact point, the centre and the top point. [3]

2.4 State where the connecting rod's instant centre is at quarter-turn, and what that implies for the rod's motion. [3]

Exercises 2.3·2.4

2.3 A 0.250 m wheel rolls without slipping at 1.80 m/s: the angular velocity (rad/s, one decimal), and the speeds of the contact point, the centre and the top point. [3]

2.3

- $\omega = v/r = 7.2$ rad/s.
- Contact 0, centre 1.80, top 3.60 m/s.

2.4 State where the connecting rod's instant centre is at quarter-turn, and what that implies for the rod's motion. [3]

2.4

- At quarter-turn both crank pin and piston move horizontally, so the perpendiculars to the rod's ends are parallel: the instant centre is at infinity.
- The rod is in pure translation: every point at 1.000 m/s.