3.1 Particle kinematics

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS particle • trajectory • polar coordinates

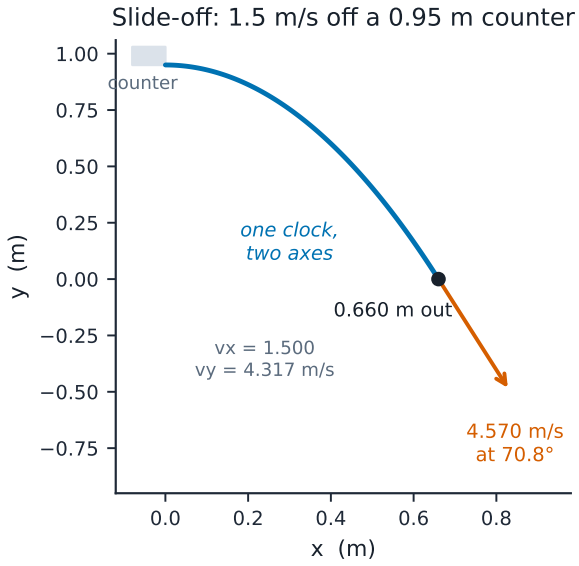
Objective

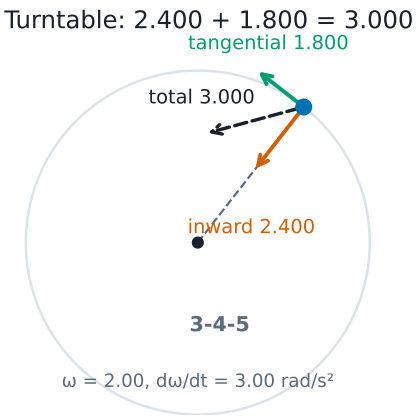
Read position, velocity and acceleration from a motion trace in Cartesian and polar components, with one shared clock.

1 Key knowledge and worked examples

■ Components and clocks

Projectile: $a_x = 0$, $a_y = -g$; both components share t. Polar: $a_r = \omega^2 r$ inward, $a_\theta = r\dot{\omega}$ tangential; ω in rad/s.





One clock, two axes - and a 3.000 made of 2.400 and 1.800

■ Worked example. The slide-off test

The till leaves a 0.95 m counter at 1.5 m/s: $t = 0.4401$ s, lands 0.6601 m out at 4.570 m/s, 70.8° below horizontal ✓.

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2 Practice

A bracket leaves a bench 1.25 m high at 2.2 m/s horizontal.

2.1 The flight time and the horizontal distance to landing (three decimals). [3]

2.2 The landing velocity: magnitude and direction (three decimals, degrees to one decimal). [4]

2.3 A turntable test runs $r = 0.450$ m at $\omega = 3.00$ rad/s speeding up at $\dot{\omega} = 2.00$ rad/s^2. The speed, both acceleration components and the total magnitude (three decimals). [5]

2.4 State, with one sentence of reason each: (a) why the horizontal and vertical motions of the bracket share one clock; (b) why a point on the turntable accelerates even at constant ω. [2]

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Solutions

2.1

- $t = \sqrt{2 \times 1.25/9.81} = 0.505$ s.
- Range $= 2.2 \times 0.505 = 1.111$ m.

2.2

- $v_y = gt = 4.952$ m/s, so $v = \sqrt{2.2^2 + 4.952^2} = 5.419$ m/s.
- Direction $\arctan(4.952/2.2) = 66.1°$ below horizontal.

2.3

- $v = \omega r = 1.350$ m/s.
- $a_r = \omega^2 r = 4.050$ m/s^2 inward; $a_\theta = r\dot{\omega} = 0.900$ m/s^2.
- Total $= \sqrt{4.050^2 + 0.900^2} = 4.149$ m/s^2.

2.4

- (a) The vertical fall fixes t; the horizontal ride ends at the same instant - one clock, two axes.
- (b) Constant ω still turns the velocity's direction: $a_r = \omega^2 r \neq 0$.

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