KINEMATICS DAY 7: MULTI-STEP PROBLEMS

WARMUP **Day 5–6 Review**

An object at $v_0 = 6.0$ m/s accelerates at 2.0 m/s² for 4.0 s. How far does it travel? Show the units of each term of $\Delta x = v_0 t + \frac{1}{2}at^2$ — and say which accumulated area each term is.

MULTI-STEP STRATEGY

Break the motion at the moment a changes. The constant-a equations only hold within one phase — that was the whole derivation (Day 5).

The link variable: one phase's final velocity is the next phase's initial velocity. Displacements add: $\Delta x_{total} = \Delta x_1 + \Delta x_2 + \ldots$

Organize first: a small table of v_0, v_f, a, t, Δx per phase prevents almost every mistake.

WE DO **Exercise 1: Reaction + Braking**

A driver moving at 20 m/s sees a hazard. She travels at constant speed during her 0.80 s reaction time, then brakes at –5.0 m/s² until stopped. Find **(a)** the reaction distance, **(b)** the braking distance, and **(c)** the total stopping distance.

CHAINING PHASES

YOU DO **Exercise 2: Accelerate, Then Cruise**

A bus starts from rest and accelerates at 2.0 m/s² for 5.0 s, then holds a constant speed for 6.0 s. **(a)** What speed does it reach? **(b)** How far does it travel in each phase? **(c)** Total distance?

YOU DO **Exercise 3: Accelerate, Then Brake**

A go-kart starts from rest, accelerates at 4.0 m/s² for 3.0 s, then immediately brakes at –6.0 m/s² until it stops. Find **(a)** its top speed, **(b)** the distance for each phase, **(c)** the total distance, and **(d)** the total time.

The cardinal sin of multi-step problems: using one equation across the whole trip. The equations of Day 5 assume constant a — if a changes, so must your equation. One phase, one table column, one set of equations.

AP FREE-RESPONSE PRACTICE

FRQ Type — Mathematical Routines: the AP exam's multi-step quantitative problem. Graders award points for the setup: write the equation in symbols first, substitute with units, then compute. A right answer with no visible reasoning earns almost nothing.

AP FRQ **The Stoplight Chase**

A car waits at a stoplight. At the moment the light turns green (t = 0), a truck passes it moving at a constant 15 m/s. The car immediately accelerates from rest at 3.0 m/s².

(a) Write a position equation x(t) for each vehicle, measured from the stoplight.

(b) At what time does the car catch the truck?

(c) How far from the light is the car when it catches the truck, and how fast is the car moving at that moment?

(d) On the same axes, sketch x-t curves for both vehicles, labeling the catch-up point.

PAPER PRACTICE

PRACTICE PROBLEMS

P1 Maximum Speed Reached

A dragster accelerates from rest at 2.5 m/s² for 8.0 s. What maximum speed does it reach?

P2 Distance in the Third Second

Starting from rest with a = 3.0 m/s², how far does an object travel between t = 2.0 s and t = 3.0 s? *Hint: x(3) – x(2).*

P3 Head-Start Chase

Runner A is 24 m ahead of runner B, jogging at a constant 8.0 m/s. B runs at a constant 12 m/s. Write both position functions and find how long B takes to catch A.

P4 Full Trip Timing

A delivery cart accelerates from rest at 2.0 m/s² until it reaches 10 m/s, then cruises at that speed. The whole trip is 60 m. Find the total time. *Hint: find the acceleration phase's time and distance first.*