KINEMATICS DAY 5: MULTI-STEP PROBLEMS

WARMUP **Day 4 Review**

An object starts at 6.0 m/s and accelerates at 2.0 m/s² for 4.0 s. How far does it travel?

- ☐ **A.** 14 m
- ☐ **B.** 24 m
- ☐ **C.** 32 m
- ☐ **D.** 40 m

Back up your check, units carried: write both terms of $\Delta x = v_i t + \frac{1}{2}at^2$ and show the unit each term carries.

Check one → convince your neighbor in one sentence.

Physics in the Wild — The Texting Tax: At highway speed (25 m/s), glancing at a phone for 1.5 s means traveling (25 m/s)(1.5 s) = 37.5 m — about nine car lengths — before your foot even *starts* moving toward the brake. Every real stopping problem is a two-phase problem: constant velocity while you react, then constant deceleration while you brake. Today is about gluing phases together.

PHASES & THE LINK VARIABLE

Break the motion at the moment the acceleration changes. Solve each phase with Day 4 equations — they only work while a is constant.

The link variable: the final velocity of one phase is the initial velocity of the next. Position adds up: $\Delta x_{total} = \Delta x_1 + \Delta x_2 + \ldots$

Organize before you calculate: a small table with v_i, v_f, a, t, Δx for each 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 4 assume constant a — if a changes, so must your equation. One phase, one table column, one set of equations.

FRQ Type 1 of 4 — 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 · MATHEMATICAL ROUTINES **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. How long does B take 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.*