KINEMATICS DAY 10: VECTORS & COMPONENTS

WARMUP **Day 8 Review**

A ball is dropped from rest from 19.6 m. Find its impact speed. (Curious coincidence with the height? It's the same ball from Day 8, Exercise 2 — coming back down.)

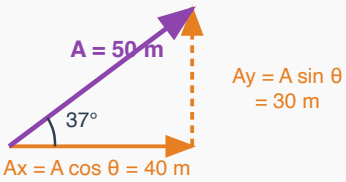
Physics in the Wild — Planes That Fly Sideways: Watch a crosswind landing video: the plane approaches the runway visibly pointed off to one side. The pilot is "crabbing" — aiming partly into the wind so the *components* of airspeed and wind add up to motion straight down the runway. Components are how physicists split one messy diagonal problem into two easy straight-line problems.

BREAKING & REBUILDING VECTORS

Break apart (θ measured from the +x axis):
$A_x = A\cos\theta$ · $A_y = A\sin\theta$

Rebuild: $A = \sqrt{(A_x^2 + A_y^2)}$ $\theta = \tan^{-1}(A_y/A_x)$

θ	30°	37°	45°	53°	60°
cos θ	0.87	0.80	0.71	0.60	0.50
sin θ	0.50	0.60	0.71	0.80	0.87



BREAK IT APART, BUILD IT BACK

WE DO Exercise 1: Components

A hiker's displacement is 50 m at 37° north of east. Find the east and north components. (Match the diagram on page 1.)

YOU DO Exercise 2: Rebuild

A velocity has components $v_x = 6.0$ m/s and $v_y = 8.0$ m/s. Find the magnitude and the angle above the x-axis.

WE DO Exercise 3: Adding Perpendicular Vectors

A delivery robot drives 12 m east, then 5.0 m north. Find the magnitude and direction of its total displacement.

Only perpendicular things Pythagorize. $A = \sqrt{(A_x^2 + A_y^2)}$ works because x and y are at 90°. Never apply it to two vectors at some random angle — break them into components first, add the components, *then* rebuild.

YOU DO Exercise 4: Perfect Cancellation

In a tug-of-war warmup, one student pulls with 60 N at 0° and another with 60 N at 180°. Find the resultant force. Which single fact about the two x-components lets you write down the resultant without computing anything?

CHALLENGE Exercise 5: Three Vectors, One Table

Add the displacements 10 m at 0°, 10 m at 90°, and 10 m at 180° by completing the table, then rebuild the resultant (magnitude and direction).

Vector	x-component (m)	y-component (m)
10 m at 0°		
10 m at 90°		
10 m at 180°		
Sum		

Notation Corner — Unit Vectors (the Physics C way)

Physics C writes components with **unit vectors**: $\hat{i}$ points one unit in +x, $\hat{j}$ one unit in +y. A vector with components (9, 12) is written $\mathbf{V = 9\hat{i} + 12\hat{j}}$. That's it — $\hat{i}$ and $\hat{j}$ are just labels that keep the components separate.

Adding is componentwise: $(9\hat{i} + 12\hat{j}) + (3\hat{i} - 2\hat{j}) = 12\hat{i} + 10\hat{j}$. Magnitude is still the Pythagorean theorem: $|9\hat{i} + 12\hat{j}| = \sqrt{(81 + 144)} = 15$. You'll see position written this way on Day 12: $r(t) = x(t)\hat{i} + y(t)\hat{j}$ — and every AP exam uses this notation.

CALC Exercise 6: Unit-Vector Warmup

Two displacement vectors: $\mathbf{A = 6\hat{i} + 3\hat{j}}$ and $\mathbf{B = 2\hat{i} - 7\hat{j}}$ (meters). **(a)** Write A + B in unit-vector form. **(b)** Find |A + B|. **(c)** Rewrite your Exercise 1 answer in unit-vector form.

PAPER PRACTICE

PRACTICE PROBLEMS

P1 Components

Find the x and y components of a 25 m/s velocity at 53° above the horizontal.

P2 Rebuild

A displacement has components (9.0 m, 12 m). Find its magnitude and direction.

P3 Two Legs

A boat travels 8.0 km east, then 6.0 km north. How far from its start is it, and in what direction?

P4 The Round Trip That Wasn't a Trip

A plane flies 40 km at 30°, then 40 km at 150°, then 40 km at 270°. Using a component table (or symmetry), show that the plane ends up exactly where it started.