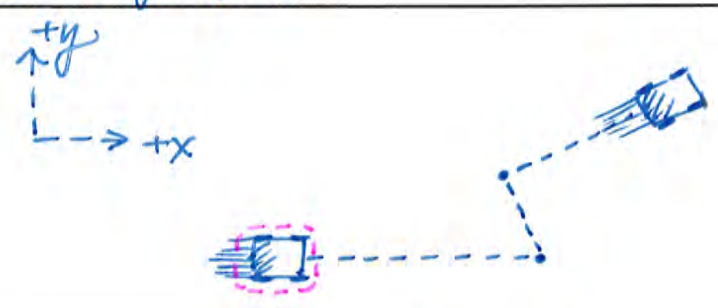


Title

Average speed

Ingredients

Sketch



At/Through

$[t_i, t_f]$

Owner

System

Frame

Quantity

Total distance traveled

Average Speed

Elapsed duration

Variable

l

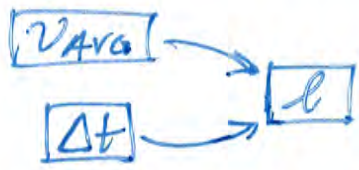
v_{AVG}

Δt

Giver

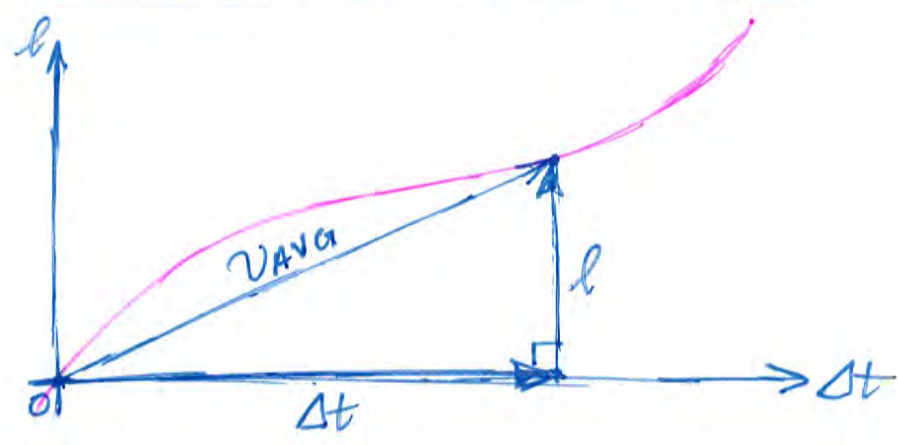
Recipe

Diagram the relationship



Graphically present quantities

On $l - \Delta t$ plot: slope of secant line



Mathematical relationship

$$v_{AVG} \Delta t = l$$

$$v_{AVG} = \frac{l}{\Delta t}$$

Recipe number **K11**: The **title** of this recipe sheet is **“Average speed”**.

The top half of this sheet consists of an **“Ingredients”** section with a row labeled “Sketch”, a row labeled “At/Through”, a row labeled “Owner”, a row labeled “Quantity”, a row labeled “Variable”, and a row labeled “Giver.” In this sheet, the row labeled “Giver” isn’t used.

For the “Sketch”, draw an overhead view showing two snapshots of a cart, with the initial snapshot showing the cart at the lower-left moving toward the right and the final snapshot showing the cart at the upper-right moving diagonally upward and rightward. Draw trailing motion-blur streaks or so-called “whooshies” to emphasize instantaneous motion in each snapshot. Draw a dashed zig-zag path connecting the initial and final snapshots so that the path consists of three segments and two corners. Draw a dashed bubble around the earlier snapshot of the cart, at the left, to indicate that the cart is the so-called “System”. Draw an arrow labeled +x to indicate that the positive-x direction points to the right. From the tail of the arrow you just drew, draw another arrow labeled +y to indicate that the positive-y direction points up the page.

In the rows of the “Ingredients” section other than the row for the sketch, document the following relationships, using flowchart paths, if helpful: There are two “Owners”, one is the “System” and the other is the “Frame”. Through the interval from initial time t_i (t-sub-i) to final time t_f (t-sub-f), the “System” accrues the “Quantity” “Total distance traveled” denoted by the “Variable” ℓ (cursive l), and for this time interval, the “System” also owns the “Quantity” “Average speed” denoted v_{AVG} (v-sub-AVG). Also for the same interval from initial time t_i (t-sub-i) to final time t_f (t-sub-f), the “Frame”, meaning the collection of rulers and clocks used to make measurements and referred together as the “frame of reference”, has the “Quantity” “Elapsed duration” denoted by the “Variable” (Δt).

The bottom half of this sheet consists of a **“Recipe”** section with a row labeled “Diagram the relationship”, a row labeled “Graphically present quantities”, and a row labeled “Mathematical relationship”.

In the row labeled, “Diagram the relationship”, draw a flowchart arrow showing that average speed v_{AVG} (v-sub-AVG) contributes to total distance traveled ℓ (cursive l). Draw another arrow showing that elapsed duration Δt also contributes to the total distance traveled ℓ (cursive l). Recite a story: “Traveling with greater average speed through a given elapsed duration results in a greater total distance traveled, but even if the average speed remained unchanged, simply traveling for a longer elapsed duration would also result in a greater total distance traveled.”

In the row labeled “Graphically present quantities”, write the title “On (cursive l- Δt) plot: Slope of secant line”. Draw a horizontal axis pointing to the right labeled with elapsed duration (Δt). Draw a vertical axis pointing up the page labeled with total distance traveled ℓ (cursive l). Label the origin of the coordinate system. Draw a curve that passes through the origin and that increases in some regions and that doesn’t decrease in any region. Draw a dot on the origin. Draw another dot for a point on the curve to the right of the origin. Draw a slanted arrow connecting the dot at the origin to the dot at the right. Label this slanted arrow with the average speed v_{AVG} (v-sub-AVG). Using this slanted arrow as a hypotenuse, draw a right triangle with a horizontal leg and a vertical leg. Add an arrowhead to make the horizontal leg become a rightward arrow. Label this horizontal arrow with elapsed duration (Δt). Add an arrowhead to make the vertical leg become an upward arrow. Label this vertical arrow with total distance traveled ℓ (cursive l).

In the row labeled, “Mathematical relationship”, write $(v\text{-sub-AVG times } \Delta t = \text{cursive l})$ and write $(v\text{-sub-AVG} = \text{cursive l divided by } \Delta t)$.