Unit 2.3 — Instantaneous Velocity (Guided Notes)

I. Race Context — Changing Velocity

- In a sprint, the runner starts from ________ ($v = 0$) in the blocks.
- They quickly increase ____________ during the drive phase.
- A well-trained athlete maintains near-_____________ velocity through the finish.

II. Instantaneous Velocity — Definition

- Instantaneous velocity: the velocity at **one specific** _________ in time.
- In 1D, include direction via ______ (e.g., + right/east, − left/west).
- Units: meters per ________ (m/s).

III. Average vs. Instantaneous vs. Constant Velocity

- Average velocity over an interval: $\bar{v}$ = **Δx / Δt**.
- Constant velocity: the **same velocity at every** ________ during the interval.
- If velocity is constant, then instantaneous = average = that ____________ value.

IV. Position–Time (x–t) Graphs: Slope Means Velocity

- On x–t, vertical change is _____________ **(Δx)**; horizontal change is _________ **(Δt)**.
- The slope (rise/run) equals **$\Delta x/\Delta t$**, which is the velocity.
- Larger positive slope → larger positive ____________; zero slope → $v = 0$; negative slope → negative velocity.

V. Constant Velocity on x–t

- Constant velocity → ____________ **line** on x–t (same slope everywhere).
- Example: slope = **+____ m/s** means the object moves that many meters each second.
- For this motion, instantaneous velocity = average velocity = **+____ m/s** at all times.

VI. Changing Velocity (Acceleration) on x–t

- Accelerated motion produces a _________ **(nonlinear)** x–t graph.
- The slope now changes with time, so ____________ changes with time.

VII. Average vs. Instantaneous from x–t

- Average velocity on an interval = slope of the _________ line across the interval.

- Instantaneous velocity at time t = slope of the ________ line at that point.

VIII. Estimating a Tangent Slope (No Calculus)

- Place a ___________ so it just touches the curve at the point of interest.
- Choose two readable ________ on the straightedge and read (t, x).
- Compute slope ≈ **Δx/Δt** → instantaneous velocity estimate.

IX. Worked Tangent Estimate (Example)

- Suppose the tangent near t = 4.0 s rises ~_____ **m** over a run of 4.0 s.
- Then v_inst ≈ **(rise/run)** = ____ **/ 4.0 s ≈ ____ m/s** (≈ 43 m/s).
- Interpretation: the instantaneous velocity at that moment is about **+____ m/s**.

X. Signs, Directions, and Common Pitfalls

- Positive slope → motion in **+x**; negative slope → motion in **−x**.
- Flat segments (slope = 0) indicate the object is ____ ______.
- Don't mix up **speed** (no sign) with **velocity** (has sign).
- Always include ______ (m, s, m/s) and sign/direction when appropriate.

XI. From x–t to v–t

- Constant velocity: x–t is straight; **v–t is a __________ line** at that value.
- Constant acceleration: x–t is curved; **v–t is a straight __________ line**.
- "Speed up then cruise": x–t curve __________ then becomes linear; v–t **rises** then ________.

XII. Reading Plateaus and Downhill Segments

- Plateau on x–t → v = __ during that interval.
- "Downhill" on x–t (x decreases) → ________ velocity (negative slope).

XIII. Units and Slope Checks

- Slope units on x–t: (meters)/(seconds) = / → matches velocity units.
- If your slope comes out in just meters or just seconds, you ________ the axes.
- Use convenient grid points; avoid extremely ______ runs.

XIV. Quick Strategy for Graph Questions

1. Identify the _____ **interval**; read x at endpoints.
2. Compute **Δx** and **Δt**; include _____.

3. Report **$\bar{v} = \Delta x/\Delta t$** with units.
4. For v_inst at a point: draw/visualize a ________ line and estimate its slope.

XV. Summary

- The slope of **x–t** is ___________.
- Constant velocity → straight x–t; instantaneous, average, and constant velocities are ______.
- With acceleration, use a ________ to estimate instantaneous velocity at a point.

Guided Examples (Unit 2.3)

Ex 1 — Draw v–t for constant velocity Prompt: Draw a velocity–time graph for an object with constant velocity **15 m/s** for the first **5.0 s**.

- Constant velocity means **v does not** ________ with time.
- On v–t, draw a ____________ line at v = +15 m/s from t = 0 to t = 5.0 s.
- Conclusion: v–t is **flat at +____ m/s** for 0–5 s.

Ex 2 — Average velocity on x–t (1 to 3 s)

- $\bar{v}$ = **$\Delta x/\Delta t$** between t = **1 s** and **3 s**.
- Read x(1) and x(3) → Δx = **x(3) − x(1)**.
- Compute $\bar{v}$ = **Δx / (3 − 1)** = **Δx / __**.
- Conclusion: The segment is rising → $\bar{v}$ is ________ (e.g., +20 m/s).

Ex 3 — Average velocity on x–t (3 to 4 s)

- $\bar{v}$ = **$\Delta x/\Delta t$** between t = 3 s and 4 s.
- The segment is ______ → Δx = 0.
- $\bar{v}$ = **0 / 1** = **__ m/s**.

Ex 4 — Average velocity on x–t (5 to 6 s)

- $\bar{v}$ = **$\Delta x/\Delta t$** between t = 5 s and 6 s.
- The segment slopes ___________ (x decreases) → Δx is ________.
- Compute using the two points; $\bar{v}$ should be ________ (negative).