Unit 2.1 & 2.2 — Position, Displacement, Speed, and Velocity (Guided Notes)

I. Position & Reference Frames (2.1)

- **Position** is an object's **location** relative to a chosen **_____** (origin).
- A **reference frame** is the **coordinate system** and **_____** you pick to measure motion. **[Image] number_line.png**
- In **1D motion**, use a **number line**: positions can be **positive (+x)** or **negative (−x)**.
- Choosing the **origin** at the **_____ point** is common, but any fixed point works.
- Always **state the frame** to avoid ambiguity (e.g., "relative to the **_____**"). **[Image] reference_frame.png**

II. Distance vs. Displacement (2.1)

- **Distance** = **total path length** traveled (**scalar**; **no direction**).
- **Displacement** = **change in position** = **x_final − x_initial** (**vector**; has **_____**).
- **Distance ≥ |displacement|**; equality only for straight-line motion **without _____**.
- Distance **cannot** be **_____**; displacement can be positive, zero, or negative.
- Example: Walk **3 m east**, then **3 m west** → distance = **6 m**; displacement = **__ m**.

III. Stockcar Race Example (2.1)

[Image] stockcar_race.png

- Cars may travel **~500 miles** around a loop; **start** and **finish** are at the **same place**.
- **Distance** is large, but **displacement** is near **_____** (net change in position ≈ 0).
- This highlights why **distance** and **displacement** are **not the same**.

IV. Interpreting Direction (2.1)

- Use sign conventions: **+x (east/right)**, **−x (west/left)**, etc.
- **Displacement sign** indicates **_____** relative to the chosen + axis.
- Reporting a displacement should include both **magnitude** and **_____** (or sign).

V. Scalars vs. Vectors (Bridge to 2.2)

- **Scalars**: magnitude **only** (distance, speed, time, mass, temperature).
- **Vectors**: magnitude **+ direction** (displacement, **velocity**, **acceleration**, force).

- Vector quantities require a **_____** or a **sign** in 1D.

VI. Speed vs. Velocity (2.2)

[Image] x15_aircraft.png

- **Speed** = **distance ÷ time** (**scalar**).
- **Velocity** = **displacement ÷ time** (**vector**).
- Same trip can have the same **average speed** but different **average _____** if direction changes.
- If **displacement** over an interval is **zero**, **average velocity** over that interval is **_____**.

VII. Average Speed (2.2)

- **Average speed** = **total distance / total time**.
- It summarizes **overall rate**, regardless of **_____** changes.
- Example: A **700 m** path covered in **20 s** → average speed = **__ m/s**.
- Average speed **does not imply** the object ever moved at that exact **_____** value.

VIII. Average Velocity (2.2)

- **Average velocity** = **total displacement / total time**.
- Requires **direction (sign)**. A **zero displacement** gives **zero average velocity**.
- Example: **Out-and-back** motion can have large distance but **__ average velocity**.

IX. Constant vs. Average Velocity (2.2)

- **Constant velocity**: **speed and direction** remain **unchanged** at every instant.
- **Average velocity**: **net change** over an interval; speeds **may vary** within the interval.
- Two trips can share the same **average speed** but not the same **_____** if directions differ.

X. Worked 1D Example (2.2)

- Suppose **x** changes from **+12 m** to **−6 m** in **3.0 s**.
- **Displacement** = (−6) − (+12) = **_____ m**.
- **Average velocity** = (−18 m) / (3.0 s) = **_____ m/s** (toward negative x).
- **Sign** indicates **_____** relative to the chosen axis.

XI. Reference Frame Dependence (2.2)

- Measured **velocities** depend on the **observer's frame** (ground vs. **moving _____**).

- In astronomy, Earth's velocity may be stated relative to the **Sun** or to the **_____**.
- Always **state or infer the frame** when comparing or combining **velocities**.

XII. Unit Check & Reporting (2.1/2.2)

- Use **SI units** unless specified: distance/displacement in **meters**, time in **seconds**, speed/velocity in **____**.
- For everyday contexts, **km/h** or **mph** may be used; **convert** carefully.
- Include **direction** (sign or words like **east/west**) for **displacement** and **velocity**.

XIII. Quick Concept Checks (2.1)

- Can **distance** ever be **less** than |displacement|? **____**.
- Can **displacement** be **zero** while distance is **nonzero**? **____** (**closed path**).
- Does displacement require a **reference frame**? **____** (to define positive/negative).

XIV. Quick Concept Checks (2.2)

- Can **average speed** be **zero** while moving? **____**; moving implies **distance > 0**.
- Can **average velocity** be **zero** while moving? **____**; if **displacement = 0**.
- Does **constant speed** guarantee **constant velocity**? Only if **_____** is constant too.

XV. Summary (2.1 + 2.2)

- **Position** is measured relative to a chosen **origin** in a **reference frame**.
- **Distance** is **path length (scalar)**; **displacement** is **net change in position (vector)**.
- **Speed** uses **distance**; **velocity** uses **displacement**.
- **Average speed ≠ average velocity** in general.
- **Constant velocity** requires **steady speed** and **unchanging direction**.
- **Frame of reference** matters for interpreting and **comparing motion**.

Guided Examples (Unit 2.1 & 2.2)

Ex 1 (2.1 Review) — Distance vs. Displacement Prompt: Explain the difference between **distance** and **displacement** in your own words.

- Distance is **_____** (**scalar**); displacement is **_____** (**vector**).
- Conclusion: Distance counts every step along the path; displacement only cares about **_____** (with **direction**).

Ex 2 (2.1 Review) — John's Evening Walk Prompt: John lives on a square block, **180 yd** per side, and walks **once around the block**.

- Distance: Perimeter = **4 × 180 = _____ yd**.
- Displacement: Starts and ends at **the same spot** → **__**.
- Conclusion: Distance = **720 yd**; Displacement = **__**.

Ex 3 (2.1 Review) — Joanna's Position Prompt: House at **0 ft**, school at **+8000 ft**. Joanna walks **100 ft west** of her house.

- East is **+**, West is **−** → position = **_____ ft**.
- Conclusion: Joanna's position is **_____ ft** relative to the origin.

Ex 4 (2.2 Review) — Average Speed on a Trip Prompt: Jane traveled **340 miles** in **8.0 h**.

- Average speed = **distance / time** = **340 / 8.0 = _____ mph**.
- Conclusion: **_____ mph**.

Ex 5 (2.2 Review) — Average Velocity on a Number Line Prompt: x goes **12** → **124** → **98 m** in **10 s**.

- Displacement = **98 − 12 = _____ m**.
- Average velocity = **Δx / Δt = _____ / 10 = _____ m/s** (**toward +x**).