Average speed practice

Seeley instructor measurements, plus the Motion in 1d review. Work the problems. Answers are on the last page.

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v_min = (d − δd) / (t + δt)
v_max = (d + δd) / (t − δt)
δv = (v_max − v_min) / 2
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(max - min) / 2. Parentheses first.

Instructor numbers

Tape, six times: 9.948 m, 9.947 m, 9.942 m, 9.943 m, 9.941 m, 9.937 m.

Ball A video is 120 frames per second. One frame is 1/120 s. Dropped at frame 100, landed at frame 289. Each end is only known to ±1 frame.

Ball	v_avg (m/s)	±
A pickleball 1	6.31	0.08
A pickleball 2	6.45	0.08
B wiffle 1	6.17	0.07
B wiffle 2	6.28	0.07
C small wiffle 1	5.97	0.07
C small wiffle 2	6.00	0.07
D golf ball	6.10	0.07

Problems

1. Best distance from the six tape readings, and the uncertainty. Several trials: δ = (highest - lowest) / 2. Write d = ___ ± ___ m.
2. Fall time from frame 100 to frame 289. Uncertainty is one frame at the drop and one frame at the landing, so δt = 2/120 s. Write t = ___ ± ___ s.
3. Best average speed, then v_min and v_max, then δv. Report v = ___ ± ___ m/s. Units on every line.
4. Same d and t. Method 2: δv/v = δd/d + δt/t. Method 3: square root of the sum of the squares of those fractions. Give both ± values in m/s.
5. Convert your best speed to km/h (multiply m/s by 3.6) and to cm/s.
6. A cart travels 240 cm in 0.80 min. Average speed in m/s.

7. Dots every 1.0 s. X is at 0, 2, 4, 6, 8 m. Y is at 0, 1, 3, 6, 10 m. Who is speeding up? Average speed of each from 0 s to 4 s. When are they the same speed? When does Y pass X?
8. The six tape readings disagree by 11 mm. If you took 20 more readings the same way, what happens to that scatter? If the tape was kinked and every reading was 2 cm short, does more data fix it? Which error is statistical, which is systematic, and which one hurts accuracy?
9. One graph starts at 0 m/s. The other is zoomed to 5.50-6.60 m/s. Which graph shows who is fastest? Do A2 and C1 overlap? Do A1 and B2? Would you bet $1,000,000 that pickleball 2 beats wiffle 2?

Answers

1. Mean is 9.943 m. Half-range is (9.948 - 9.937) / 2 = 0.0055 m. **9.943 ± 0.0055 m.**
2. 189 / 120 = 1.575 s. δt = 2/120 = 0.0167 s. **1.575 ± 0.0167 s.**
3. v = 9.943 / 1.575 = 6.31 m/s. v_min = 9.9375 / 1.5917 = 6.24 m/s. v_max = 9.9485 / 1.5583 = 6.38 m/s. δv = 0.07 m/s. **6.31 ± 0.07 m/s.** The table lists pickleball 1 as 6.31 ± 0.08. Same speed. They rounded the ± up a hundredth.
4. δd/d = 0.00055. δt/t = 0.0106. Method 2: **±0.070 m/s**. Method 3: **±0.067 m/s**. Method 3 is smaller because it is the hypotenuse, not the sum. On the exam, the min/max line is enough if you only keep one.
5. **22.7 km/h** and **631 cm/s**.
6. 2.40 m / 48 s = **0.050 m/s**.
7. X is constant speed. Y is speeding up. X is **2.0 m/s** from 0 to 4 s. Y is **2.5 m/s**. Same speed only from 1 s to 2 s, when both move 2 m. Y passes X at **t = 3 s** (both at 6 m). Same speed is not the pass.
8. The 11 mm scatter is statistical. More trials shrink it. A kinked tape is systematic. More trials do not fix it. The readings can be precise and still be inaccurate.
9. The zoomed graph shows who is fastest. A2 (6.37 to 6.53) and C1 (5.90 to 6.04) do not overlap. A1 (6.23 to 6.39) and B2 (6.21 to 6.35) do overlap. A2 and B2 also do not overlap, so the table says pickleball 2 is faster than wiffle 2. Two drops is still a bad million-dollar bet.