

AI-AUGMENTED ENGINEERING DYNAMICS: A CONVERSATIONAL APPROACH

ME345 ENGINEERING DYNAMICS · HOMEWORK 3 · CHAPTERS 1–2 · PARTICLE KINEMATICS

Engineering Homework 3

Virtual Engineering Laboratory — Particle Kinematics

Rectilinear Motion → Projectile Motion → Normal–Tangential Motion → Stopping Distance

Suggested Assessment · 100 points

target effort $\approx$ 2.5 hours (3 hours maximum) · type all answers and paste all VEL screenshots directly into this document



AI First Engineering

Figure: AI First Engineering (AIFE) course logo

Taner Onsay, Ph.D. · © 2026 AI First Engineering ·

AI use is allowed and encouraged — as an assistant. AI may help you operate the Virtual Engineering Laboratory, check an equation, help you read a graph, debug a calculation, or challenge your reasoning. But the predictions, the VEL runs and screenshots, the hand calculations, the validation tables, and the final engineering judgment must be YOUR OWN work — not an AI transcript. Assessment rewards evidence + reasoning + validation, not polished prose.

VEL IS THE EXPERIMENT — NOT THE ANSWER KEY

In this homework you will use the AIFE Virtual Engineering Laboratory (VEL) — four Particle Motion Animator tools at lab.aifirstengineering.org/pma — to conduct numerical experiments. The VEL displays numbers; it does not tell you whether they are right. For the quantities specified in each Part you must independently calculate the result from particle-kinematics theory and decide whether the simulation is physically and mathematically consistent. Do not copy displayed values as answers.

PREDICT → EXPERIMENT → CALCULATE → VALIDATE → EXPLAIN

the ME345 course loop: OBSERVE → IDEALIZE → MODEL → SOLVE / ANALYZE → VALIDATE → REPORT

PERSONALIZED PARAMETERS — read before you start

Wherever a parameter is given as a range, select your own value to **ONE decimal place** inside that range (for example 2.7 m/s, not 2.75 m/s and not 3). Record your selected values in the table at the start of each Part **before** you begin that investigation. To select a value, use the provided ME345-HW3 Random Number Generator. Enter the lower and upper limits of the specified range and record the generated value. (the release speed in Part B is the one exception: it is tuned, not generated). Do not change a recorded value unless the question asks for a parameter study. Every student therefore runs a different virtual experiment; the instructor grades your method, your evidence and your validation — not agreement with a single answer.

Evidence. Paste the requested VEL screenshots into the dashed boxes (Windows: Win+Shift+S · Mac: Cmd+Shift+4, then Ctrl+V / Cmd+V). A screenshot must show the parameter settings and the numerical readouts, not only the picture.

Time guide: Part A ≈ 25 min · Part B ≈ 30 min · Part C ≈ 55 min · Part D ≈ 30 min. Each Part follows the same cycle: PREDICT → EXPERIMENT → CALCULATE → VALIDATE → EXPLAIN. Every question tells you what to determine and what to submit; the ANSWER lines and dashed boxes are where your work goes.

PART A · Rectilinear Motion — Predict the Reversal Before You Play It (15 points · ≈ 25 min)

Reversal: slow down, turn around, come back

Open the **Rectilinear Motion Animator** (lab.aifirstengineering.org/pma/rectilinear). Use the **Describe it** definition mode and load the **Example Motion** “Reversal: slow down, turn around, come back”. Play it once: the particle moves RIGHT while slowing down, stops, and comes back LEFT. You will now build your own version of this motion and predict it before you play it.

A0 — Record your parameters. Choose v_0 (entered as **Cruise speed**) and the acceleration magnitude a (entered as **Speed-up a**). The acceleration acts opposite to v_0 , so the particle slows, stops and reverses.

Parameter	Allowed range	MY VALUE (one decimal place)
Initial velocity v_0 (Cruise speed)	1.5 to 3.5 m/s	
Acceleration magnitude a (Speed-up a)	0.5 to 1.5 m/s ²	
Start position s_0	0 m (keep the default)	0 m

A1 — Predict (5 points). Complete BEFORE you press APPLY / GENERATE MOTION. The particle starts at $s_0 = 0$ moving RIGHT at v_0 with a constant acceleration of magnitude a directed LEFT.

1. Calculate the reversal time t_{rev} (the instant at which $v = 0$) and the reversal position s_{rev} from the constant-acceleration equations. Write the equation, the substitution and the result:

Predicted: $t_{\text{rev}} = v_0 / a =$ _____ s $s_{\text{rev}} =$ _____ m

2. Sketch $s(t)$, $v(t)$ and $a(t)$ from $t = 0$ to $t = 2 \cdot t_{\text{rev}}$. Label the axes with units and mark t_{rev} on each sketch. Your $v(t)$ sketch must show v changing sign at t_{rev} .

3. Predict: at the reversal instant $v = 0$. Is a also zero at that instant? Answer YES or NO and give one sentence of reasoning.

SKETCH OR PASTE YOUR PREDICTED $s(t)$, $v(t)$ AND $a(t)$ HERE

(three sketches, made before running the VEL — a photo of a hand sketch is fine)

ANSWER A1 (item 3):

A2 — Run the Virtual Experiment (3 points). The VEL brings every SLOW DOWN segment to rest exactly at the segment's end time, so segment 1 must end at your predicted t_{rev} (three decimal places are enough). Enter the segment table:

#	Start (s)	End (s)	Direction	Behavior
1	0	t_{rev}	RIGHT	SLOW DOWN
2	t_{rev}	$2 \cdot t_{\text{rev}}$	LEFT	SPEED UP
3	$2 \cdot t_{\text{rev}}$	$3 \cdot t_{\text{rev}}$	LEFT	SLOW DOWN

Set **Start position $s_0 = 0$** , **Cruise speed $= v_0$** , **Speed-up $a = a$** ; clear rows 4–6; press **APPLY / GENERATE MOTION**, then **PLAY**. Tick **Preview full graphs**.

Setup check: during segment 1 the a readout must equal $-a$ (your value). If it does not, your t_{rev} entry is wrong — correct it before continuing.

Required evidence (ONE screenshot): the VEL window with the time slider at the reversal instant ($v = 0.000$ m/s), showing the segment table, the parameter boxes, the t , s , v , a readouts and the three graphs.

PASTE VEL EVIDENCE FOR THE REVERSAL MOTION (PART A) HERE

(segment table + parameter boxes + readouts at $v = 0 + s(t)$, $v(t)$, $a(t)$ graphs — click here and paste — Ctrl+V / Cmd+V)

A3 — Calculate and Validate (4 points). Using the constant-acceleration equations (not the VEL), calculate the time at which the particle returns to $s = 0$ and its velocity at that instant. Write the equation and the substitution. Then scrub the VEL to each instant, read the VEL values, and complete the table (t_{rev} and s_{rev} are your A1 values).

Quantity	VEL	Hand calculation	% difference
Reversal time t_{rev} (s)			
Reversal position s_{rev} (m)			
Return time to $s = 0$ (s)			
Velocity at return to $s = 0$ (m/s)			

% difference = $|VEL - \text{hand}| / |\text{hand}| \times 100 \%$. Validation statement: state whether every row agrees within rounding ($\leq 1 \%$). If a row does not, name the input you would check first.

ANSWER A3:

A4 — Explain (3 points).

Record the acceleration the VEL displays at the reversal instant ($v = 0$): $a = \underline{\hspace{2cm}}$ m/s².

Then explain in two or three sentences why $v = 0$ at the reversal does NOT require $a = 0$ at that instant. Use $a = dv/dt$ (a is the slope of $v(t)$) and your $v(t)$ and $a(t)$ graphs. State whether your A1 item 3 prediction was correct.

ANSWER A4:

PART B · Projectile Motion — Design and Validate a Basketball Shot (20 points · ≈ 30 min)

Ideal planar projectile: $a_x = 0$, $a_y = -g$

Open the **Projectile Motion Animator** (lab.aifirstengineering.org/pma/projectile).

Load the preset **3-point (FIBA / NCAA, L = 6.75 m) — makes it** ($v_r = 8.73$ m/s, $\theta_r = 50^\circ$, $h_r = 2.10$ m, $L = 6.75$ m, rim height $h_{rm} = 3.05$ m, $g = 9.81$ m/s²).

PLAY it once and note where the VEL reports the outcome: the result line under the SIDE / TRAJECTORY view (for example NOTHING BUT NET, FRONT RIM, MISS SHORT).

B0 — Design your own successful shot (5 points). Keep $h_r = 2.10$ m and $L = 6.75$ m.

1. Select your release angle. Use the random number generator to select θ_r between 38.0° and 58.0° . If you obtain 50.0° , generate another value. Keep this angle fixed while designing your shot.

2. Design the shot. Adjust v_r until the VEL reports a made basket. Start near 8.5 m/s and use 0.1 m/s changes to find the successful range. You may then use 0.05 m/s changes for fine adjustment. Record the successful v_r and θ_r . Two decimal places are allowed for v_r .

If you cannot obtain a made basket at your generated angle after turning v_r , adjust θ_r by 0.5° and repeat. Record the final angle you actually used.

Parameter	Allowed range	MY VALUE
Release angle θ_r	38.0° to 58.0°	
Release speed v_r	7.5 to 10.5 m/s (two decimals allowed)	
Release height h_r	2.10 m (keep)	2.10 m
Distance to hoop L	6.75 m (keep)	6.75 m
VEL result line	must be a made basket	

Required evidence (ONE screenshot): the SIDE / TRAJECTORY view at the end of the shot with Show full trajectory on, showing your v_r and θ_r settings, the readouts and the result line reporting the made basket.

PASTE VEL EVIDENCE FOR YOUR SUCCESSFUL SHOT (PART B) HERE

(parameter settings + full trajectory + readouts + result line — click here and paste — Ctrl+V / Cmd+V)

B1 — Record, Calculate and Validate at one instant (11 points). Use the 0.05 s step buttons to stop at ONE instant t^* between 0.3 s and 0.9 s (ball in flight, before the rim). Record t^* and the five readouts in the VEL column. Then calculate the same five quantities by hand from the ideal projectile equations with the initial conditions the VEL uses ($x_0 = 0$, $y_0 = h_r = 2.10$ m, $v_{x0} = v_r \cos \theta_r$, $v_{y0} = v_r \sin \theta_r$, $a_x = 0$, $a_y = -9.81$ m/s²).

Write each equation with your numbers substituted (typed, or a photo of your work).

$$\begin{aligned}x(t) &= v_r \cos \theta_r \cdot t & y(t) &= h_r + v_r \sin \theta_r \cdot t - \frac{1}{2} g t^2 \\v_x(t) &= v_r \cos \theta_r & v_y(t) &= v_r \sin \theta_r - g t & |v| &= \sqrt{v_x^2 + v_y^2} \\t^* &= \underline{\hspace{2cm}} \text{ s}\end{aligned}$$

Quantity at t^*	VEL	Hand calculation	% difference
x (m)			
y (m)			
v_x (m/s)			
v_y (m/s)			
v (m/s)			

Validation statement: are all five rows within 1 % (the VEL displays two decimals)? If a row exceeds 1 %, identify the cause (typical causes: wrong t^* , angle in radians, h_r omitted in y).

ANSWER B1: *validation statement + worked substitutions (typed here or attached as a photo)*

B2 — Explain (4 points).

1. Explain why v_x stays constant while v_y decreases linearly during the flight. Use $a_x = 0$ and $a_y = -g$, and name the physical assumption that makes $a_x = 0$.

2. Name ONE real effect that the VEL model leaves out (the model statement is printed at the bottom of the VEL control panel).

ANSWER B2:

ONE MOTION, TWO INDEPENDENT EQUATIONS. With $a_x = 0$ and $a_y = -g$ the x and y equations are independent; only the common time t connects them. A shot is “designed” by choosing v_r and θ_r so that $y = h_{rm}$ when $x = L$.

PART C · Normal–Tangential Motion — The Figure-8 Challenge (45 points · ≈ 55 min)

Curvature, Center of Curvature, and Acceleration

Open the **Normal–Tangential Motion** animator (lab.aifirstengineering.org/pma/normal-tangential) and load the preset **Figure-8 Race Track — speeding up**. The path is $x = A \sin u$, $y = B \sin u \cos u$ with $A = 3$ m and $B = 5$ m (printed under Path type); one lap is 24.8 m long. The particle starts at the crossing O ($s = 0$) with speed $v(t) = v_0 + a_t \cdot t$, so in $T = 12$ s it completes several laps. On a curved path $\mathbf{a} = \mathbf{a}_t \mathbf{u}_t + \mathbf{a}_n \mathbf{u}_n$ with $\mathbf{a}_t = d\mathbf{v}/dt$ and $\mathbf{a}_n = v^2/\rho$, where ρ is the local radius of curvature and $\mathbf{u}_n$ points toward the local center of curvature O'.

C0 — Record your parameters. Keep the path ($A = 3$ m, $B = 5$ m), the SPEEDING UP mode and the duration $T = 12$ s.

Parameter	Allowed range	MY VALUE (one decimal place)
Initial speed v_0	2.0 to 5.0 m/s	
Tangential acceleration a_t	0.3 to 1.2 m/s ²	
Duration T	12 s (keep)	12 s

Before PLAY, switch on the display options **Centre of curvature & ρ (osculating circle)**, **Moving t–n frame ($\mathbf{u}_t$, $\mathbf{u}_n$)**, **Normal acceleration $\mathbf{a}_n$** and **Total acceleration $\mathbf{a}$** , and set GRAPH DISPLAY to **Acceleration**.

C1 — Predict (5 points). Answer BEFORE you press PLAY, using Figure C1. Predict in words (you may also mark the figure):

- Where on the track is ρ smallest? Give the location as a description and approximate (x, y) coordinates, and one sentence of reasoning.
- In this speeding-up run, will the largest $\mathbf{a}_n$ of the whole run occur at the same place and the same time as the smallest ρ ? Answer YES or NO and give one sentence of reasoning based on $\mathbf{a}_n = v^2/\rho$.
- What is ρ at the crossing O, where the path is locally straight, and what is $\mathbf{a}_n$ there?

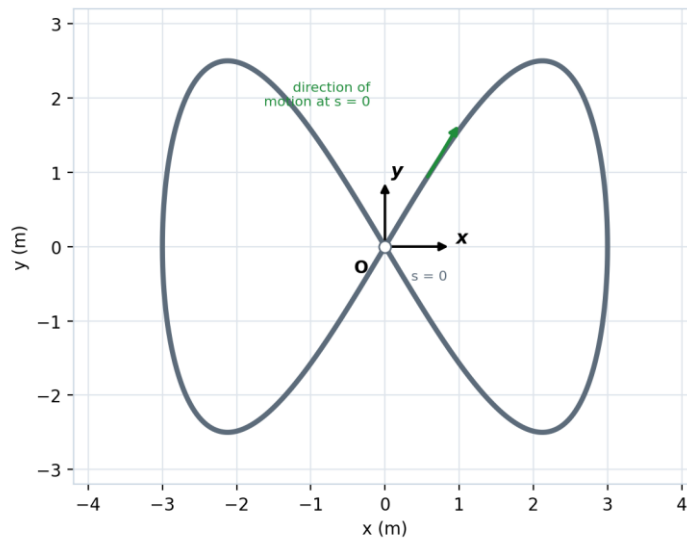


Figure C1 — the Figure-8 race track ($A = 3 \text{ m}$, $B = 5 \text{ m}$). The particle starts at O ($s = 0$) and moves in the direction shown.

ANSWER C1:

C2 — Find the Minimum Radius of Curvature and Validate a_n (20 points). **APPLY / GENERATE MOTION**, then **PLAY**. How to find $\rho_{\min}$: the peaks of the purple a_n curve on the Acceleration graph occur where ρ is smallest. Click the **FIRST** peak (first lap), then use the 0.1 s step buttons until the ρ readout reaches its smallest value. Record the readouts at that instant in the VEL column. Then calculate $a_n = v^2/\rho$ and $|a| = \sqrt{(a_t^2 + a_n^2)}$ from the displayed v , ρ and a_t , and complete the Hand and % columns for those two rows.

Quantity at $\rho_{\min}$ (first lap)	VEL	Hand calculation	% difference
Time t (s)		—	—
Speed v (m/s)		—	—
Tangential acceleration a_t (m/s ²)		—	—
Radius of curvature $\rho_{\min}$ (m)		—	—
Normal acceleration $a_n = v^2/\rho$ (m/s ²)			
Total acceleration $ a = \sqrt{(a_t^2 + a_n^2)}$ (m/s ²)			
Location: approximate (x, y) from the 1 m grid		—	—

1. Describe where $\rho_{\min}$ occurs (which lobe, which part of the lobe). How many points on one lap have this same $\rho_{\min}$? Was your C1 item 1 prediction correct?
2. Rounding check: the VEL displays ρ to 0.01 m. Compare your calculated a_n with the VEL value. Do they agree within the precision of the displayed values? If yes, state that the VEL is validated at this instant.

3. Compare a_t with a_n at this instant and explain in one sentence why $|a| \approx a_n$ here.

Required evidence (ONE screenshot): the PARTICLE ON THE PATH scene at the $\rho_{\min}$ instant showing the particle, the u_t – u_n frame, O' with the osculating circle, and the t , s , v , a_t , a_n , $|a|$, ρ readouts.

PASTE VEL EVIDENCE AT THE MINIMUM- ρ LOCATION (PART C2) HERE

(particle + Figure-8 + u_t , u_n frame + O' and osculating circle + readouts — click here and paste — Ctrl+V / Cmd+V)

ANSWER C2 (items 1–3):

DO NOT ASSUME THE SOFTWARE IS CORRECT. VALIDATE IT. A simulation is a model with a display attached. The number on the screen earns trust only after an independent calculation reproduces it within the precision of the display.

C3 — Follow the Center of Curvature (10 points). Compare your $\rho_{\min}$ instant from C2 (right lobe) with TWO more instants: the crossing O (particle at $x \approx 0$, $y \approx 0$; the first pass is at $s \approx 12.4$ m) and one instant inside the LEFT lobe. Pause at each and complete the table. “Driver’s left / right” means the side of the path to the left or right of the direction of travel.

Instant	t (s)	ρ (m)	a_n (m/s ²)	u_n points to the driver’s LEFT / RIGHT / undefined	Where is O' ? (inside which lobe / far away)
1 — $\rho_{\min}$ (from C2)					
2 — crossing O					
3 — left lobe					

Required evidence (ONE screenshot): the scene at your LEFT-lobe instant with the u_t – u_n frame and O' / osculating circle visible. Your C2 screenshot is the evidence for instant 1; no screenshot is needed at the crossing.

PASTE VEL EVIDENCE FOR THE LEFT-LOBE INSTANT (PART C3) HERE

(scene with u_t , u_n , O' and the osculating circle + readouts — click here and paste — Ctrl+V / Cmd+V)

1. Does the Figure-8 have ONE fixed center of curvature? Answer YES or NO. State what O' represents at any instant, and contrast with a circular path of radius R (where is O' , and what is ρ , on a circle?).
2. From your table: on which side of the path (driver's left or right) is u_n in the right lobe, and on which side in the left lobe? State what happens to ρ , u_n and a_n at the crossing.

ANSWER C3:

C4 — Minimum ρ versus Maximum Normal Acceleration (10 points). Search the COMPLETE run (0 to 12 s): click the highest peak of the purple a_n curve, then refine with the 0.1 s step buttons until a_n is largest. Record the readouts at that instant.

Quantity at $a_{n,max}$ (complete run)	VEL readout
Time t (s)	
Arc length s (m) and lap number (lap = 1 + whole part of $s / 24.8$)	
Speed v (m/s)	
Radius of curvature ρ (m)	
Normal acceleration $a_{n,max}$ (m/s ²)	
Location: approximate (x, y) and description	

1. Place and time: is $a_{n,max}$ at a point with the same ρ as your ρ_{min} (one of the equivalent tightest bends)? Is it at the same instant as your C2 reading? Using $a_n = v^2/\rho$, state which factor — v^2 or ρ — makes a_n larger at this pass than at your C2 instant.
2. Ratio check: compute $R1 = a_{n,max} / a_n(C2)$ and $R2 = (v \text{ at } a_{n,max} / v \text{ at } C2)^2$. If ρ is the same at both instants, $a_n = v^2/\rho$ requires $R1 = R2$ within rounding. Report $R1$ and $R2$ and state whether they agree; if they do not, compare your two ρ values.
3. For the preset **Figure-8 Race Track — constant speed**, would $a_{n,max}$ occur at the same time as ρ_{min} ? One sentence.

ANSWER C4:

PART D · Stopping Distance — One Motion, Two Phases (20 points · ≈ 30 min)

Applied rectilinear motion: reaction phase + braking phase

A STOPPING MANEUVER IS TWO RECTILINEAR MOTIONS IN SEQUENCE

PHASE 1 — REACTION. The driver has recognized the hazard but has not yet applied the brakes. During the reaction time t_r : $a = 0$ and $v = v_0$, so the vehicle covers the reaction distance $d_r = v_0 t_r$.

PHASE 2 — BRAKING. The vehicle decelerates at constant a_b (magnitude) until $v = 0$, covering the braking distance $d_b = v_0^2 / (2 a_b)$ in the braking time $t_b = v_0 / a_b$.

TOTAL STOPPING DISTANCE = REACTION DISTANCE + BRAKING DISTANCE
 $d_{\text{stop}} = d_r + d_b$

Open the **Stopping Distance Animator** (lab.aifirstengineering.org/pma/stopping-distance). Keep the available distance to the hazard at its default $d_{\text{avail}} = 50$ m. The VEL assigns an effective deceleration a_b to each road condition (printed under the Road condition buttons) and reports SAFE STOP or COLLISION.

D0 — Record your parameters. Your road condition is assigned by the LAST DIGIT of your UMID. Do NOT write your ID anywhere in this document — use the digit only to pick the row.

Parameter	Allowed range / rule	MY VALUE
Vehicle speed v_0	55.0 to 85.0 km/h (one decimal place)	
Driver reaction time t_r	0.6 to 1.5 s (one decimal place)	
Road condition	last digit 0–3 → DRY · 4–6 → WET · 7–9 → SNOW or ICE (record which)	
Effective deceleration a_b (m/s ²)	read from the VEL for your road condition	
Available distance d_{avail}	50 m (keep)	50 m

D1 — Predict (2 points). Before **APPLY / GENERATE TEST**, record two predictions: (a) which is larger in your case, d_r or d_b ? (b) SAFE STOP or COLLISION within 50 m? Also select your prediction under “Your prediction” in the VEL.

ANSWER D1:

D2 — Experiment, Calculate and Validate (12 points). Enter your values, **APPLY / GENERATE TEST, PLAY**. Record the DISTANCE BREAKDOWN cards in the VEL column. Then calculate by hand, showing each equation and substitution:

1. v_0 [m/s] = v_0 [km/h] / 3.6

2. $d_r = v_0 t_r$
3. $d_b = v_0^2 / (2 a_b)$ and $t_b = v_0 / a_b$, with the a_b the VEL displays for your road condition
4. $d_{stop} = d_r + d_b$; compare with $d_{avail} = 50 \text{ m} \rightarrow$ SAFE STOP or COLLISION
 $v_0 = \underline{\hspace{2cm}} \text{ km/h} = \underline{\hspace{2cm}} \text{ m/s}$

Quantity	VEL	Hand calculation	% difference
Reaction distance d_r (m)			
Braking distance d_b (m)			
Braking time t_b (s)			
Total stopping distance d_{stop} (m)			
Verdict: SAFE STOP or COLLISION			—

Required evidence (ONE screenshot): the VEL at the end of the run showing your speed, reaction time, road condition, the ROAD VIEW result banner and the DISTANCE BREAKDOWN cards.

PASTE VEL EVIDENCE FOR YOUR STOPPING TEST (PART D2) HERE

(parameters + road view result + distance breakdown cards — click here and paste — Ctrl+V / Cmd+V)

Validation statement: does your calculation reproduce the VEL distances within 1 % and its verdict? Were your D1 predictions (a) and (b) correct?

ANSWER D2:

D3 — Explain (6 points).

1. Sketch $v(t)$ for the complete maneuver (or paste the VEL $v(t)$ graph and annotate it). Label t_r and $t_r + t_b$, the rectangle whose area is d_r , and the triangle whose area is d_b .
2. State $a = dv/dt$ in each phase and explain why this gives a horizontal, then a linearly decreasing, $v(t)$.

3. Prediction — doubled reaction time: BEFORE rerunning the VEL, predict d_r , d_b and d_{stop} for a reaction time of $2 \cdot t_r$. State which term of $d_{stop} = v_0 t_r + v_0^2/(2 a_b)$ changes and which does not, and whether d_{stop} doubles.

4. Experiment: type $2 \cdot t_r$ into the reaction-time box (typed values above 1.5 s are accepted), **APPLY / GENERATE TEST**, and record the VEL values. Compare with your prediction.

Quantity	Original t_r	Doubled t_r — prediction	Doubled t_r — VEL
Reaction distance d_r (m)			
Braking distance d_b (m)			
Total stopping distance d_{stop} (m)			
Verdict			

SKETCH OR PASTE $v(t)$ WITH BOTH PHASES AND BOTH AREAS LABELED (PART D3) HERE

(hand sketch photo, or the VEL Velocity $v(t)$ graph with your labels)

ANSWER D3 (items 2–4):

TWO PHASES, TWO CHAPTER-1 MOTIONS. Each phase is a constant-acceleration rectilinear motion with its own a ; the total stopping distance is the sum of the two areas under $v(t)$.

OPTIONAL · Reflection (ungraded)

In three to five sentences: which VEL result surprised you most, and which hand calculation changed how you read the simulation?

REFLECTION (optional):

SUBMIT · Evidence Checklist & Human Review

Submit ONE completed Word document — this file — containing:

- Parameter tables A0, B0, C0 and D0 completed according to the stated parameter rules and ranges.
- Predictions made before PLAY — A1 (t_{rev} , s_{rev} , three sketches, item 3), C1 (three items), D1 (a and b), D3 item 3
- VEL screenshots (5 in total) — Part A (reversal instant), B0 (made shot), C2 (p_{min}), C3 (left-lobe instant), D2 (stopping test)
- Hand calculations with equations and substitutions, and completed VEL / Hand / % difference tables — A3, B1, C2, D2
- Validation statements — A3, B1, C2 (item 2), D2
- Explanations — A4, B2, C3, C4, D3
- Human review statement signed and dated (below)

SUBMIT ONE COMPLETED HOMEWORK DOCUMENT. Keep all required answers and VEL evidence in this document rather than as separate screenshot, video or image files. Follow your instructor's submission and file-naming requirements.

HUMAN REVIEW: (Part A: 15 · Part B: 20 · Part C: 45 · Part D: 20 · Total: 100 points)

"I reviewed the VEL experiments, predictions, hand calculations, validation tables and engineering conclusions in this submission and confirm that they represent the work I performed and reviewed."

Human reviewed and approved: _____

Student name: _____ **Date:** _____

AI assists. Humans observe. Humans verify. Humans decide. Humans approve.

Suggested Assessment Rubric — 100 points

Used by the instructor and, where applicable, by an AI grading agent. All required evidence must appear inside this document. Student parameters differ; the grader checks the method, the internal consistency of each student's own numbers and the validation reasoning, not agreement with one universal answer.

Criterion	What full credit looks like	Pts
Part A — Rectilinear reversal (A0–A4)	Parameters in range, one decimal; $t_{rev} = v_0/a$ and $s_{rev} = v_0^2/(2a)$ with substitutions (A1: 5); $s(t)$, $v(t)$, $a(t)$ sketched before PLAY with correct shapes (parabola with horizontal tangent at t_{rev} , straight $v(t)$ through zero, constant a); segment 1 ends at t_{rev} and the a readout equals $-a$, screenshot at $v = 0$ (A2: 3); return time $2 \cdot t_{rev}$ and return velocity $-v_0$ calculated and validated within 1 % (A3: 4); explanation that $a = dv/dt$ is the slope of $v(t)$, which is unchanged at the reversal, so $a \neq 0$ when $v = 0$ (A4: 3).	15
Part B — Basketball shot (B0–B2)	θ_r from the generator and v_r tuned by the stated procedure, VEL reports a made basket, screenshot with result line (B0: 5); one instant t^* recorded and x , y , v_x , v_y , $ v $ calculated from the stated equations with substitutions, all within 1 %, validation statement (B1: 11); $a_x = 0$ because gravity is the only force (no drag), $a_y = -g$, one omitted effect named (B2: 4).	20
Part C — Figure-8 (C0–C4)	Predictions committed before PLAY (C1: 5); ρ_{min} located on the first lap with readouts and screenshot showing the frame, O' and the osculating circle; $a_n = v^2/\rho$ and $ a $ reproduced within the rounding uncertainty $0.005/\rho$; four equivalent ρ_{min} points per lap identified; $ a \approx a_n$ because $a_t \ll a_n$ (C2: 20); three instants tabulated, no single center, u_n on the driver's right in one lobe and left in the other, $\rho \rightarrow \infty$ and $a_n = 0$ at the crossing, contrast with the circle (C3: 10); $a_{n,max}$ found over the complete run, same ρ / different time, v^2 argument, ratio check $R1 \approx R2$, constant-speed contrast (C4: 10).	45
Part D — Stopping distance (D0–D3)	Road condition by the rule, no ID shown; both predictions recorded (D1: 2); $km/h \rightarrow m/s$, d_r , d_b , t_b , d_{stop} with substitutions, within 1 % of the VEL, verdict reproduced, screenshot (D2: 12); $v(t)$ with both phases, t_r , $t_r + t_b$ and both areas labeled; $a = 0$ then $a = -a_b$ explained with $a = dv/dt$; doubled- t_r prediction made before the rerun shows only d_r doubles, compared with the VEL rerun (D3: 6).	20
	TOTAL	100