

FUNDAMENTALS OF AI-AUGMENTED ENGINEERING

CHAPTER 5 / HOMEWORK 5

Engineering Homework

The Diode That Sets the Current — A Bias-Point Certification

Use It · Run It · Break It · Choose It · Converged Fast Is Not Converged Right

Suggested Assessment · 20 points

target effort ≈ 70–90 minutes · type all answers and paste the required screenshot directly into this document



AI First Engineering

Figure: AI First Engineering (AIFE) course logo

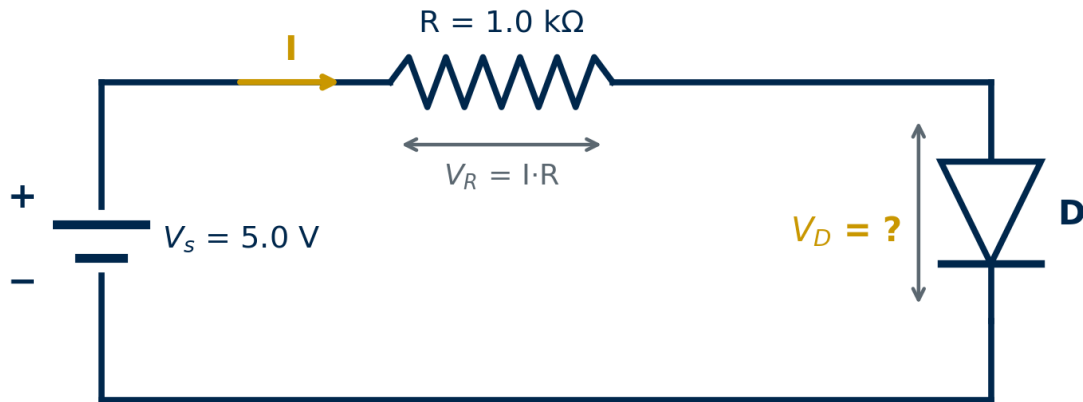
Taner Onsay, Ph.D. & Sebnem Onsay · © 2026 AI First Engineering ·

AI use is allowed and encouraged — as an Engineering Analyst turning Critic that may propose the start, the slope and the stop. But every prediction must be committed in writing before you compute, every derivative and every start must be checked by you, the screenshot must show YOUR OWN Python session running on your computer — not an AI transcript — and every AI claim you record must carry your own ACCEPT / MODIFY / REJECT verdict. Assessment rewards evidence + convergence discipline + validation, not polished prose.

THE ENGINEERING CONTEXT — a diode that sets the current

A sensor board powers a silicon signal diode from a $V_s = 5.0$ V supply through a series resistor $R = 1.0$ k Ω (the figure below). The diode is not a resistor: its current grows exponentially with the voltage across it, so the bias point — the diode voltage V_D and the loop current I that the circuit actually settles at — cannot be solved by algebra. The board's specification is blunt: the bias voltage must be stated to the nearest millivolt, and the current must follow from it. The manufacturer's datasheet, not the programmer, owns the diode parameters; the specification, not the programmer, owns the tolerance.

An engineer must certify, by computation, the bias point of this circuit — and decide whether the current is inside the board's operating window of 4.0 to 5.0 mA. Every rule of thumb about silicon diodes says V_D lands somewhere near 0.6–0.7 V; every digit beyond that must be earned. This is the first homework in which a root must be REACHED BY SLOPE — Newton-Raphson from a justified start — and then interrogated: converged, yes; but from where, how fast, and is it right?



KVL around the loop: $V_s = I \cdot R + V_D$ with $I = I_s (e^{V_D/(nV_T)} - 1)$

Figure: The series circuit for this homework — supply V_s , resistor R , diode D , loop current I (clockwise), and the unknown diode voltage V_D . The model box and parameter table below remain the authoritative values for computation.

THE DIODE MODEL — provided; no electronics course required

Kirchhoff's voltage law says the supply voltage is shared between the resistor and the diode: $V_s = I \cdot R + V_D$. The resistor obeys Ohm's law; the diode obeys the Shockley equation, $I = I_s \cdot (\exp(V_D / (n \cdot V_T)) - 1)$, with saturation current I_s and thermal voltage $n \cdot V_T$. Eliminating I gives one equation in the one unknown V_D .

Then:

A larger $V_D \rightarrow$ a much larger diode current $\rightarrow$ a larger resistor drop: $f(V_D)$ rises steeply and without limit, from $f(0) = -V_s$ upward. The BIAS POINT V_{D^*} is the voltage at which $f(V_{D^*}) = 0$. Written the chapter's way, with its slope:

$$f(V_D) = V_D + R \cdot I_s \cdot (e^{V_D/(n \cdot V_T)} - 1) - V_s = 0$$

$$f'(V_D) = 1 + (R \cdot I_s / (n \cdot V_T)) \cdot e^{V_D/(n \cdot V_T)}$$

V_D = diode voltage (V) · I = loop current (A) · R = resistance (Ω) · I_s = saturation current (A)
 · $n \cdot V_T$ = thermal voltage (V) · V_s = supply (V)

The thermal voltage is 0.02585 V — 25.85 millivolts — at room temperature; keep every voltage in volts and every current in amperes inside f . The values below are instructional design parameters for this assignment. Everything you compute is a MODEL PREDICTION for an idealized diode — not yet bench evidence about a real one.

Quantity	Symbol	Value	Units
Supply voltage	V_s	5.0	V
Series resistance	R	1000	Ω
Saturation current (datasheet)	I_s	1.0×10^{-12}	A
Thermal voltage $\times$ ideality (room temperature)	$n \cdot V_T$	0.02585	V

Quantity	Symbol	Value	Units
Operating window for the current (board specification)	I	4.0 – 5.0	mA
Required resolution of V_D (board specification)	—	nearest 0.001	V
Tolerance that follows from it	tol	0.0005	V

Time guide: Part A ≈ 10 min · Part B ≈ 12 min · Part C ≈ 8 min · Part D ≈ 12 min · Part E ≈ 15 min · Part F ≈ 8 min · Part G ≈ 12 min · Part H ≈ 7 min. If you are far past 90 minutes, submit what you have with honest notes — do not expand the assignment.

PART A · Write It & Commit Predictions (≈ 10 min)

Study the figure together with the context, model, and parameter boxes above — observe the circuit before computing anything about it. Then write the question in the chapter's shape and commit — in writing, before any computation. Wrong is fine; uncommitted is not. Do not edit these later.

A1 — The Problem, in Your Own Words. In one or two sentences: what exactly are you asking the computer to find, and what engineering decision depends on the result?

ANSWER A1:

A2 — The Sign Has Meaning. $f(V_D) = V_D + R \cdot I_D(V_D) - V_s$. Say what each sign means physically for THIS loop — in terms of the voltages around it, not algebra.

$f(V_D) < 0$ means:

$f(V_D) > 0$ means:

$f(V_D) = 0$ means:

A3 — Prediction P1 · The Bias Point. Before computing: roughly where will V_D land, and will the current be INSIDE the 4.0–5.0 mA window? Commit, then give one sentence of reasoning (a silicon rule of thumb is a fine reason).

P1: $V_D \approx$ _____ V **INSIDE the window** ☐ **OUTSIDE** ☐ **too close to call** ☐

REASONING P1:

A4 — Prediction P2 · The Price of Speed. Newton will start from $V_0 = 0.6$ V (a justified start) and must stop when the correction falls below $\text{tol} = 0.0005$ V. How many steps? Commit a number: 2? 5? 20?

P2: _____ **Newton steps from 0.6 V**

A5 — Prediction P3 · The Convenient Start. A teammate starts from $V_0 = 0$ (“the simplest number”). Same tolerance. How many steps will THAT take — about the same, twice as many, ten times as many? Commit now — Part E will hold you to it.

P3: _____ **Newton steps from 0 V**

PART B · Own the Model — Two Evaluations by Hand (≈ 12 min)

The program in Part E is provided nearly complete. But a provided program is not a black box, and a derivative is not trusted by hoping: before anything runs, evaluate the model AND its slope yourself. These hand values are your known cases for the rest of the homework.

B1 — Quantities and Roles. Complete the Role column: is each quantity an input parameter (set once, never changes), the unknown the iteration moves (the state), an intermediate computed from the state, or an output (reported at the end)?

Quantity	Symbol	Units	Role — your answer
Supply voltage	V_s	V	
Saturation current	I_s	A	
Diode voltage	V_D	V	
Diode current $I_D = I_s \cdot (e^{(V_D/nV_T)} - 1)$	I_D	A	
$f(V_D) = V_D + R \cdot I_D - V_s$	f	V	
$f'(V_D)$ — the slope	f'	V per V	

B2 — f and f' at a Silicon Start, by Hand. Evaluate $f(0.6)$ step by step using the model box — the exponent $V_D/(n \cdot V_T)$, the exponential, I_D , $R \cdot I_D$, then f — and then $f'(0.6)$. Show the arithmetic (a calculator handles $e^{23.21}$; keep the exponent to two decimals). Then answer: what does the SIGN of $f(0.6)$ already tell you about the bias point, before any search?

ANSWER B2: exponent = _____ $e^{(...)} =$ _____ $I_D(0.6) =$ _____ mA $R \cdot I_D =$ _____ V $f(0.6) =$ _____ V (sign _____)
 $f'(0.6) =$ _____ V/V

What the sign at 0.6 V says about the bias point:

B3 — A Second Evaluation — and a Sign Change. Now evaluate $f(0.5)$ the same way. Do the two hand values have opposite signs? Write the sentence that makes $[0.5, 0.6]$ a certified bracket — and name the theorem’s hinge that the sentence relies on. (Newton will not need this bracket; Part F will.)

ANSWER B3: $I_D(0.5) =$ _____ mA $f(0.5) =$ _____ V (sign _____)
 $f'(0.5) =$ _____ Opposite signs? YES ☐ NO ☐

Certification sentence:

PART C · The Domain, the Slope, and the Guard (≈ 8 min)

Newton has no bracket to protect it. What protects it is the engineer: a physical domain written down before the loop runs, a derivative checked at one point, and a guard that refuses to walk off the map.

C1 — The Domain from Physics. Explain, without a calculator, why every physically meaningful V_D lies between 0 and V_s — what would a negative diode voltage, or one above the supply, mean for the loop? Then evaluate f at both ends ($f(0)$ by hand; $f(5.0)$ in Python — it is astronomically large) and record both values with their signs.

$f(0) = \underline{\hspace{2cm}} \text{ V}$ (why, physically: _____)

$f(5.0) = \underline{\hspace{2cm}} \text{ V}$ (why so large: _____)

C2 — Check the Slope at One Point. Chapter 5's habit: check f' before it steers anything. Evaluate f at 0.60 and at 0.61, form rise over run, and compare with your hand $f'(0.6)$ from B2. (a) Compute the percent difference using $|f'_{\text{two-point}} - f'_{\text{exact}}| / |f'_{\text{exact}}| \times 100\%$. (b) Why is the two-point estimate a little LARGER than the exact slope at 0.60 (think about the shape of an exponential over the interval)? (c) Why does f climb the whole way, so that exactly one bias point exists?

ANSWER C2:

C3 — The Guard in One Line. Write the single line of Python that stops the loop if an iterate leaves the domain $0 < V_D < V_s$, and say what the program should tell the engineer when it fires — and what it should NOT do.

ANSWER C3:

PART D · Newton by Hand — Steps and the Stopping Rule (≈ 12 min)

No AI, no Python: start from $V_0 = 0.6 \text{ V}$ and run Newton by hand. Row 0 uses your B2 values; each later row needs one new exponential. The arithmetic is Part B's; the only judgment per row is WHETHER THE CORRECTION IS SMALL ENOUGH TO STOP. **Values provided to reduce arithmetic:** $e^{(0.5836/0.02585)} = e^{22.58} = 6.39 \times 10^9$; $e^{(0.5757/0.02585)} = e^{22.27} = 4.70 \times 10^9$.

n	V_n (V)	$f(V_n)$ (V)	$f'(V_n)$ (V/V)	correction $-f/f'$ (V) · V_{n+1} (V) · $ \Delta \leq 0.0005$?
0	0.6000	(from B2)	(from B2)	
1				
2				

D1 — Read Your Corrections. Write the three corrections in order. Do they shrink — and how fast? Chapter 5 promised that near a root the correct digits roughly double each step; is that visible yet, or is the first step still “far away”?

D1: corrections _____ $\rightarrow$ _____ $\rightarrow$ _____ **V** **digits doubling?**
YES ☐ **NOT YET** ☐ **because:** _____

D2 — The Stopping Rule. The specification fixes $\text{tol} = 0.0005$ V. After which row does $|\text{correction}| \leq \text{tol}$ — or does the hand table not get there? State the rule Chapter 5 uses to stop (and the two checks that follow it), and say why “three iterations” is not a rule.

D2: stop after row _____ **(or: not yet — the correction is still** _____ **V)** **rule:** _____ **then check:** _____
 _____ **and** _____

D3 — Reconcile P2. Compare the number of steps you actually needed with your committed P2 prediction. In one sentence: what controls Newton’s step count — the starting point, the tolerance, or both? Explain from your run.

ANSWER D3:

PART E · Newton in Python — the Guarded Run (≈ 15 min)

The program below is complete except for the two marked lines. Copy it into your Python environment (IDLE, Spyder, Jupyter, VS Code — any is fine), complete ① and ②, and run it from the justified start with the specification’s tolerance. Your Part B hand values tell you exactly what the first row must contain.

```
# diode_bias.py — Chapter 5: bias point by Newton-Raphson
import math
Vs, R = 5.0, 1000.0          # supply (V), resistor (ohm)
Is, nVT = 1.0e-12, 0.02585  # saturation current (A), n*V_T (V)

def diode_I(V):              # Shockley model: current at diode voltage V
    return Is * (math.exp(V / nVT) - 1.0)

def f(V):                    # KVL: f(V) = 0 at the bias point
    return V + R * diode_I(V) - Vs

def fprime(V):               # slope of f (V per V)
    return 1.0 + R * Is / nVT * math.exp(V / nVT)

V = 0.6                      # a justified start (silicon: ~0.6-0.7 V)
tol = 0.0005                 # from the requirement: nearest millivolt
steps = 0
while True:
    dV = _____          # COMPLETE ①: the Newton correction -f/f'
    V = V + dV
    steps = steps + 1
    print(steps, V, f(V), dV)
    assert 0.0 < V < Vs, "left the circuit's world"
    if _____:          # COMPLETE ②: stop on the CORRECTION, not a count
        break
    assert steps < 500, "no convergence"
print(steps, "steps: V_D =", V, "V   I =", diode_I(V) * 1000, "mA   V_R =", Vs - V, "V")
```

E1 — Evidence. Paste ONE screenshot showing your completed program together with its printed rows and final line, with no unresolved error. This is the only screenshot this homework requires.

PASTE PYTHON CODE / OUTPUT SCREENSHOT HERE

(click here and paste your screenshot — Ctrl+V / Cmd+V)

E2 — Result & Known-Case Checks. Report the run and test it against your own evidence: the printed row 1 must reproduce your hand row 1 (D); the final V_D must satisfy KVL — $V_R + V_D = 5.0\text{ V}$ — and the current must be the same whether computed from the diode equation or from the resistor.

Steps run: _____ (P2 predicted _____ → agree? YES ☐ NO ☐)

Final: $V_D =$ _____ V $I =$ _____ mA $V_R =$ _____ V

Printed row 1 agrees with hand row 1? YES ☐ NO ☐ $V_R + V_D =$ _____ V ≈ 5.0 ? YES ☐ NO ☐ I from the resistor (V_R/R) = _____ mA $\approx I$ from the diode? YES ☐ NO ☐

E3 — Read the Log. From your printed rows: do the corrections collapse — by roughly the same factor each step, or faster and faster? At which row does digit-doubling become visible? Is the residual $f(V)$ at the end small in VOLTS — and what does “small” mean against a 0.0005 V tolerance?

ANSWER E3:

E4 — The Convenient Start. Change only the start to $V = 0.0$ and rerun (raise the safety count if you must). Record the steps and the first five iterates. Follow what actually happens: the first Newton step jumps from 0.0 V to approximately 5.0 V . From there, explain why the corrections are almost exactly -0.02585 V — the thermal voltage — until the iterate reaches $\approx 0.7\text{ V}$. Then compare with P3.

E4: steps from 0.0 = _____ first iterates: _____ → _____ → _____ → _____
P3 predicted _____ → agree? YES ☐ NO ☐
why the crawl: _____

E5 — Justified Digits. Python printed many digits. Using the final correction and the specification as your evidence, write V_D and I with the digits the requirement justifies — and no more.

E5: $V_D =$ _____ V $I =$ _____ mA (last correction: _____ V; tolerance: 0.0005 V)

Optional — Excel. Build the first three rows of the same algorithm in Excel: V, the exponent, I_D, f, f', the correction $-f/f'$, the next V, and an IF on $\text{ABS}(\text{correction}) \leq \text{tol}$; copy the row down. If you do, paste a small screenshot after E1. Same algorithm, new platform — the Newton logic is the method.

PART F · Trust It — Bound, Certificate & the Bracket-First Rule (≈ 8 min)

F1 — Who Owns 0.0005 V? Name the specification that fixed the tolerance, and explain why “tol = 0.0005” is not a Python setting you were free to change. Then the Chapter 5 question: does a final correction of 4×10^{-5} V PROVE that V_D is within 0.0005 V of the model’s root? What kind of evidence is it?

ANSWER F1:

F2 — The Two-Evaluation Certificate. Newton gave you no bound. Buy one: evaluate $f(V_D - 0.0005)$ and $f(V_D + 0.0005)$. Record both values with their signs and state what Chapter 4's contract now lets you certify.

F2: $f(V_D - 0.0005) =$ _____ V (sign _____) $f(V_D + 0.0005) =$
 _____ V (sign _____) opposite? YES ☐ NO ☐ certified: $V_D =$
 _____ $\pm$ _____ V

F3 — Bracket First, Move Intelligently Second. From the physics cage $[0, 1.0 \text{ V}]$ (why is 1.0 V a safe upper wall for a silicon diode?), take THREE bisection halvings by hand using the signs of f (values: $f(0.5) = -4.25$, $f(0.75) = +3981$, $f(0.625) = +27.3 \text{ V}$), then start Newton from the midpoint of the surviving bracket. Count the computational work honestly: each endpoint or bisection midpoint check requires an f evaluation only; each Newton step requires both f and f' . Compare this hybrid with bisection alone from $[0, 1.0]$ to ± 0.0005 (10 halvings), and with Newton from 0.0 (Part E4). Which information bought which saving?

ANSWER F3:

PART G · AI Critic & BREAK THE AI — Audit the Convergence (≈ 12 min)

In Chapter 5 the analyst becomes a critic — it may propose the start, the slope and the stop, and precisely because it may, every proposal must arrive with its reasons and every convergence claim must say what it does NOT certify. The rule has not changed: AI assists. Human verifies. Engineer decides.

G1 — Hand AI Your Model. Give any capable AI assistant your $f(V_D)$, your derivative, your justified start and the 0.0005 V tolerance, with a prompt close to this:

“Here is my root-finding problem: $f(V) = V + R \cdot I_s \cdot (\exp(V/nVT) - 1) - V_s$ with $V_s = 5.0$ V, $R = 1000$ Ω , $I_s = 1e-12$ A, $nVT = 0.02585$ V [paste your f and f']. I plan to use Newton-Raphson from $V_o = 0.6$ V with tolerance 0.0005 V on the correction. Before any code: check my derivative at $V = 0.6$, tell me whether my start is defensible and what could go wrong from a start of 0 V or 3 V, and say exactly what Newton’s convergence will and will not certify here. Do not run anything yet.”

Record ONE meaningful claim from the AI analysis, verbatim (one or two lines — not the whole conversation).

ANSWER G1:

G2 — Your Verdict on the Analysis. Judge that claim as the engineer. Do not manufacture disagreement: ACCEPT is a fully legitimate verdict when you have verified it — say how.

ACCEPT ☐ MODIFY ☐ REJECT ☐

WHY (1–2 sentences):

BREAK THE AI — The Certified Memo. A different AI assistant was asked to certify the bias point and produced the memo and code below. Its Newton loop is flawless: the correction-based stop, the derivative, the guard, all present; the run converges in two steps with a residual of 10^{-11} . Every number in it is real — run the code yourself if you doubt it. And it is wrong. Something no convergence test covers is being sold.

AI CERTIFICATION MEMO — verbatim, with its code

“Newton-Raphson from $V_o = 0.7$ V with a correction-based stop converged in 2 iterations to $V_D = 5.0000$ V, residual 1.5×10^{-11} V, every iterate inside $[0, V_s]$. The diode therefore drops the entire supply; the loop current is $I = 2 \times 10^{-13}$ A — effectively zero — and the series resistor can be omitted from the board.” Its diode function: `def I_D(V): return I_s * (math.exp(V / nVT) - 1) with nVT = 25.85`

G3 — Attack the Physics, Not the Syntax. Using your own Part B, E and F evidence, give at least THREE specific reasons the memo’s engineering claim does not stand. Aim at what convergence covers and what it does not: is the Newton loop wrong, or is something upstream of it wrong? What does the memo’s own $f(0.7)$ equal, and how does that compare with your hand value? What does a silicon diode dropping 5 V tell you before any computation?

ANSWER G3:

G4 — Verdict on the Memo. One check, one sentence.

ACCEPT ☐ MODIFY ☐ REJECT ☐

WHY (one sentence):

PART H · Converged Fast Is Not Converged Right — Certify (≈ 7 min)

H1 — What Convergence Does NOT Establish. Your run converged — corrections collapsed, residual tiny, iterate inside the domain — and you even bought a bound in F2. State TWO things this still does not establish about the real board. (Think: the datasheet I_s and its temperature dependence, the resistor's tolerance, the ideality factor, the idealized model, the units.)

ANSWER H1:

H2 — The Engineering Certification. Complete the statement. Every blank matters — report the voltage to the digits your evidence justifies, not every digit Python printed.

“Under the stated diode model and parameters ($V_s = 5.0\text{ V}$, $R = 1000\ \Omega$, $I_s = 1.0 \times 10^{-12}\text{ A}$, $n \cdot V_T = 0.02585\text{ V}$), I wrote $f(V_D) = V_D + R \cdot I_D(V_D) - V_s$ and its derivative, checked f' at 0.6 V against a two-point slope (_____ vs _____), and justified the start $V_0 = 0.6\text{ V}$ because _____. Newton with the specification's 0.0005 V tolerance converged in _____ steps (predicted _____; corrections _____ $\rightarrow$ _____ $\rightarrow$ _____ $\rightarrow$ _____), every iterate inside $[0, V_s]$, to $V_D =$ _____ V . Two evaluations at $V_D \pm 0.0005\text{ V}$ ($f =$ _____, _____) certify $V_D =$ _____ $\pm 0.0005\text{ V}$.

Known cases: $V_R + V_D =$ _____ V ; I from the diode = _____ mA and from the resistor = _____ mA . The current I_S ☐ / IS NOT ☐ inside the $4.0\text{--}5.0\text{ mA}$ window, with a margin of _____ mA .

I recommend:

_____.
This is a model-based computational conclusion under the stated assumptions — Newton's convergence covers the computation only, and the two-evaluation certificate covers the model's root only; neither validates I_s , $n \cdot V_T$, the resistor, the temperature, or the model, and a bench measurement is required before final acceptance.”

Evidence behind this certification (one line each): ① hand-evaluated known cases and the checked slope ② justified start + domain guard ③ correction-based stop; predicted vs run steps ④ the certificate; the memo's failure named.

EVIDENCE ①:

EVIDENCE ②:

EVIDENCE ③:

EVIDENCE ④:

CONVERGED FAST IS NOT CONVERGED RIGHT.

Two Newton runs, both flawless, both “converged” — one found the bias point of the circuit, the other found the bias point of a circuit with a thermal voltage a thousand times too large. The iteration kept its promise both times; the promise covered only the computation. Carry the principle into every root you will ever sprint to: a collapsing correction is evidence, not a certificate — the start, the slope, the domain and, above all, the model are the engineer’s to check, and a silicon diode that drops five volts should have screamed before any loop ran.

SUBMIT · Evidence Checklist & Human Review (≈ 3 min)

Submit ONE completed Word document — this file — containing all of the following:

- ☐ A1 problem statement · A2 sign meanings · committed predictions P1, P2, P3 — unedited
- ☐ B1 roles table · B2 hand evaluation of $f(0.6)$ and $f'(0.6)$ with arithmetic and the sign sentence · B3 second evaluation + certification sentence
- ☐ C1 domain with both endpoint values and reasons · C2 slope check with percent agreement and the single-crossing argument · C3 the guard line
- ☐ Part D Newton table · D1 corrections read · D2 stopping rule and the two checks · D3 reconciliation
- ☐ E1 code + log screenshot · E2 steps, result and known-case checks · E3 log reading · E4 the 0-V crawl · E5 justified digits
- ☐ F1 tolerance ownership and evidence-vs-bound · F2 two-evaluation certificate · F3 bracket-first hybrid with evaluation counts
- ☐ G1 recorded AI claim · G2 verdict · G3 three-point attack on the memo · G4 memo verdict
- ☐ H1 two not-established items · H2 completed certification with all four evidence lines
- ☐ Human review statement signed and dated (below)

SUBMIT ONE COMPLETED HOMEWORK DOCUMENT

Keep all required evidence in this document rather than as separate Python or image files. A separate .py file is welcome as an optional attachment, but the document must stand on its own. If this homework is being used as part of a course, follow your instructor’s submission and file-naming requirements.

HUMAN REVIEW

"I reviewed the predictions, hand evaluations, slope check, code, screenshot, log, certificate, and written responses in this submission and confirm that they represent the work I performed, that I can explain every line of the program, and that I can say exactly what its convergence does and does not certify."

Human reviewed and approved: _____

Student name: _____ Date: _____

Suggested Assessment Rubric — 20 points

Used by the instructor and, where applicable, by an AI grading agent. All required evidence must appear inside this document — the grader will not open separate Python or image files. A submission whose program converges, but whose certification does not separate convergence from correctness, cannot earn a high score.

Criterion	What full credit looks like	Pts
Write it & committed predictions (A1–A5)	A1 names both the computed quantity (the bias point V_D , hence I) and the decision (the 4.0–5.0 mA window). A2 gives all three signs a physical meaning around the loop. P1–P3 committed with reasoning. Prediction correctness is NOT graded — commitment and reasoning are.	2
Model ownership & hand evaluations (B1–B3)	Roles column correct (f' is an intermediate). B2 arithmetic shown — exponent, exponential, I_D , $R \cdot I_D$, f , f' — consistent with the key; the sign at 0.6 V interpreted for the bias point. B3 second value correct; certification sentence names the sign change AND continuity as the hinge.	3
Domain, slope check & guard (C1–C3)	Both endpoint values with physical reasons; the two-point slope compared with $f'(0.6)$ to a stated percent, the curvature reason given, the single crossing argued (both terms of f climb); the guard written with what it reports and what it must not do.	2
Newton by hand — steps and the stopping rule (D1–D3)	Rows 0–2 with corrections and next iterates; corrections read (shrinking, digit-doubling not yet visible at step 1); the stop stated as $ \Delta \leq \text{tol}$ followed by the residual and domain checks — never a count; P2 reconciled with the start-decides insight.	3
Python run — guarded, inspected, verified (E1–E5)	Both marked lines completed correctly (correction $-f/f'$; stop on $ dV \leq \text{tol}$); screenshot shows the rows and final line; step count and row 1 match the hand table; KVL and the two current computations agree; log reading correct (collapse accelerates; residual in volts); the 0-V crawl reproduced (≈ 175 steps) and explained through the thermal voltage; digits justified.	4
Trust it — bound, certificate, bracket-first (F1–F3)	Tolerance ownership named; a small correction identified as evidence, not proof; f at $V_D \pm 0.0005$ V evaluated with opposite signs and the certificate stated; the hybrid's evaluations counted honestly (each Newton step = f and f') and compared with bisection alone and with the crawl.	2

Criterion	What full credit looks like	Pts
AI critic & BREAK THE AI (G1–G4)	One verbatim AI claim judged with independent justification. The memo attacked with at least three specific, evidence-based reasons — the thermal voltage in millivolts, the hand-value mismatch at 0.7 V (+572 vs –4.3), the physically absurd 5-V silicon diode and near-zero current, the scope of convergence. Verdicts graded on justification, never on which box is checked.	3
Converged fast ≠ converged right — certification (H1–H2)	Two legitimate not-established items. Certification complete and internally consistent: slope check, start justified, steps predicted vs run, corrections, V_D with justified digits, the two-evaluation certificate, KVL and current checks, window verdict with margin, a real recommendation, the model-based caveat intact, all four evidence lines filled.	1
	TOTAL	20