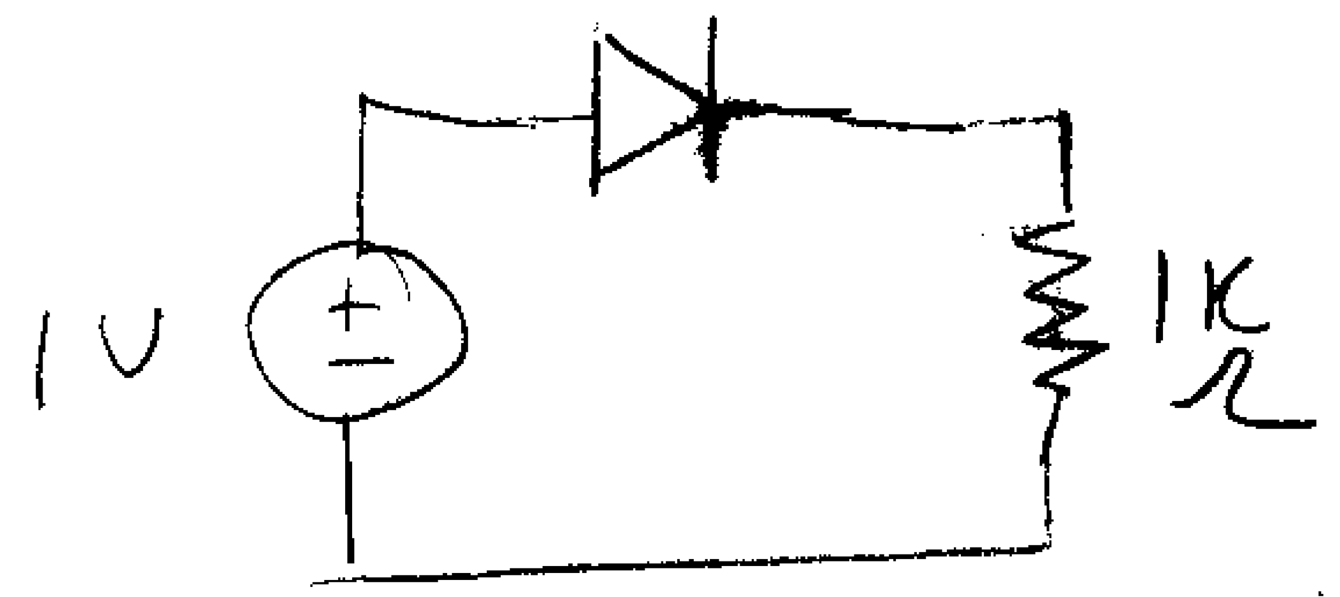
EE 40

Homework 6 Solutions

Problem 1: 20 pts Using the load-line method means finding the intersection between the diode curve and the Thevenin equivalent of the attached linear circuit.



Diode equation: $I = I_0 \left(e^{\frac{qV}{kT}} - 1\right)$

$= 10^{-15}\left(e^{V/.026} - 1\right)$

Thevenin equivalent: $R_{TH} = 1K$, $V_{TH} = 1V \Rightarrow I_{SC} = 1mA$

I_{SC} is y-intercept, $-1/R_{TH}$ is slope

$$I = -\frac{1}{1000} V + 1mA$$

The intersection can be found graphically (next page), or by solving the equations simultaneously (need computer!)

Solution: $V = 0.688\ V \quad I = 0.312\ mA$

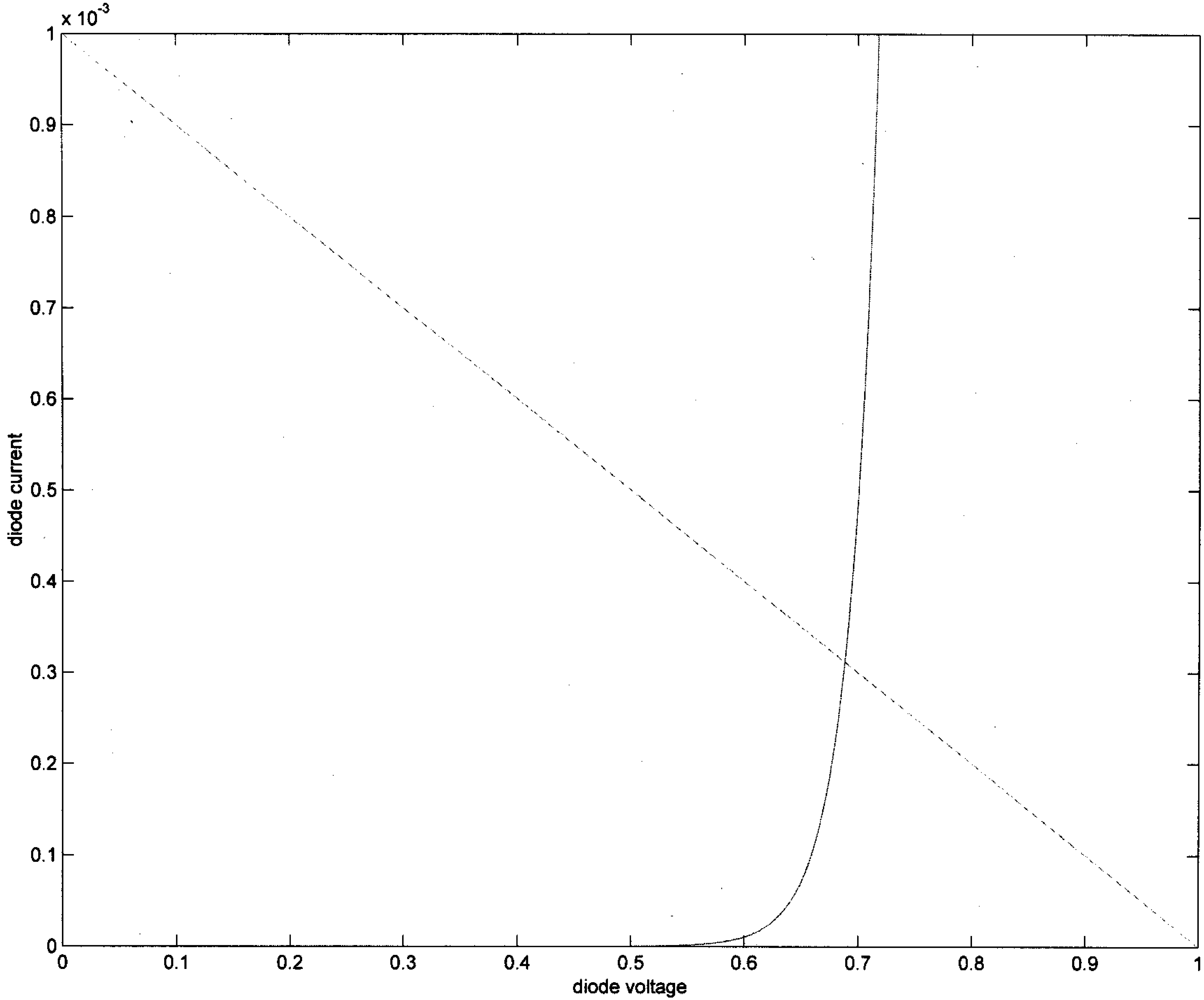
20 points for correct equations and any solution within 0.6-0.7V

Subract 5 points for each math error

Subtract 5 points for minor error in linear equation

Sutract 10 points for major error in linear equation

(minimum score of 0 points).



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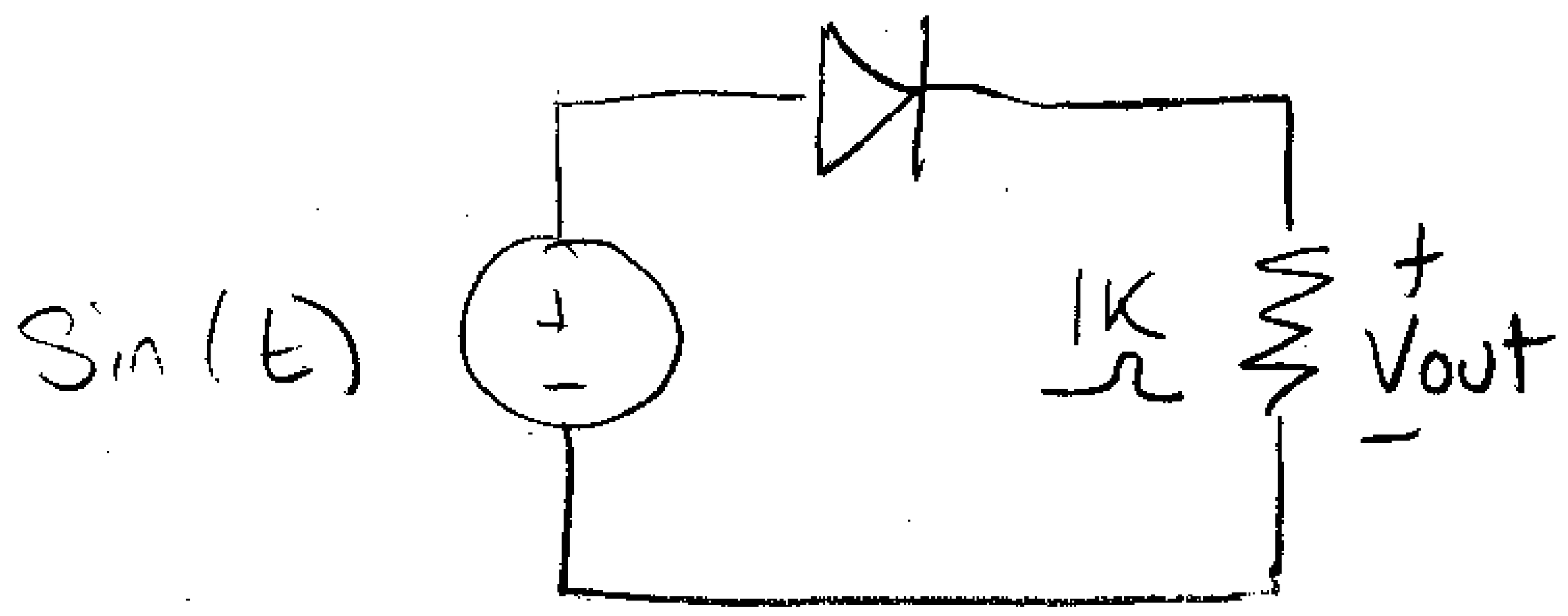
Problem 2: 20 points

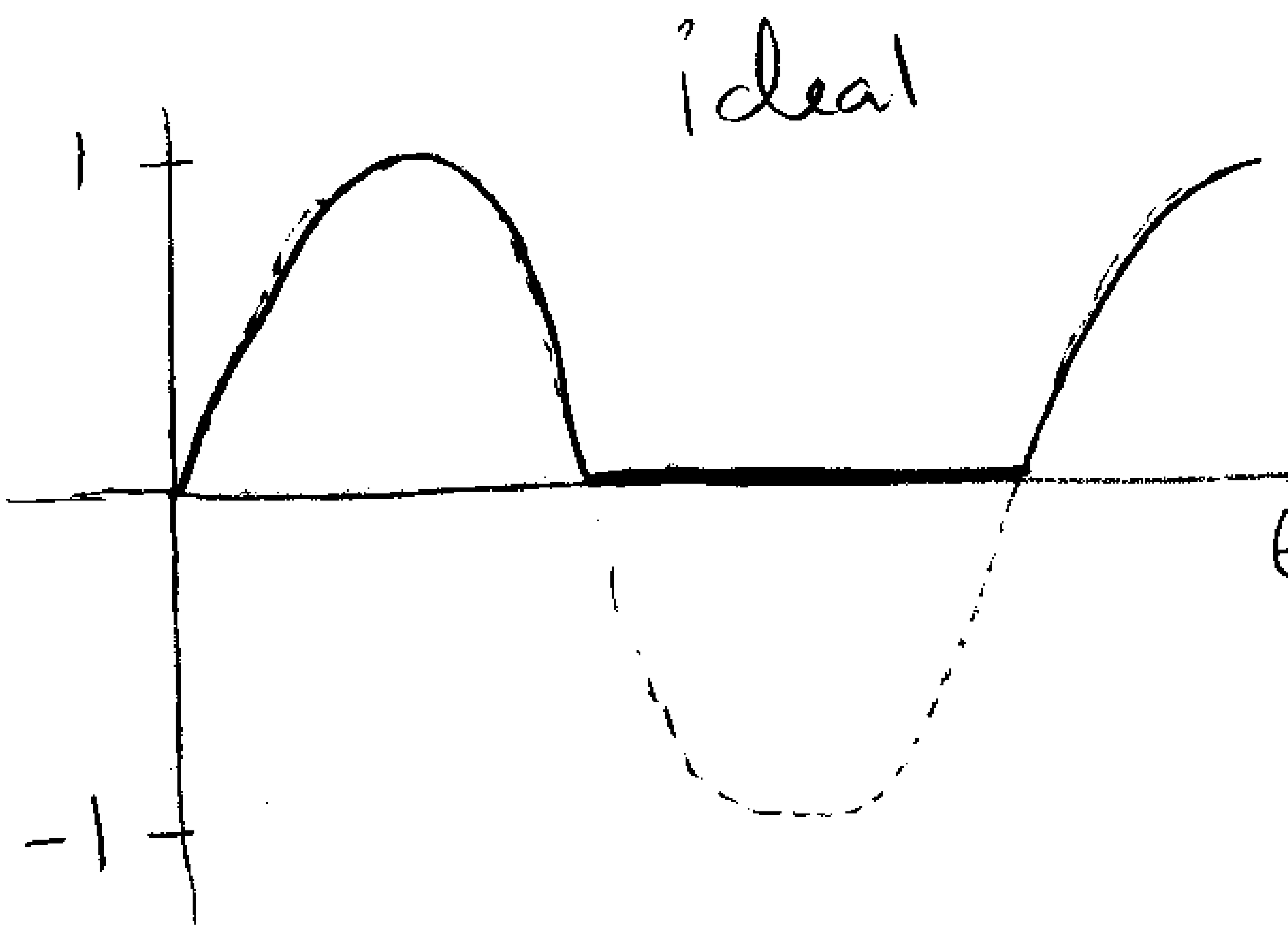


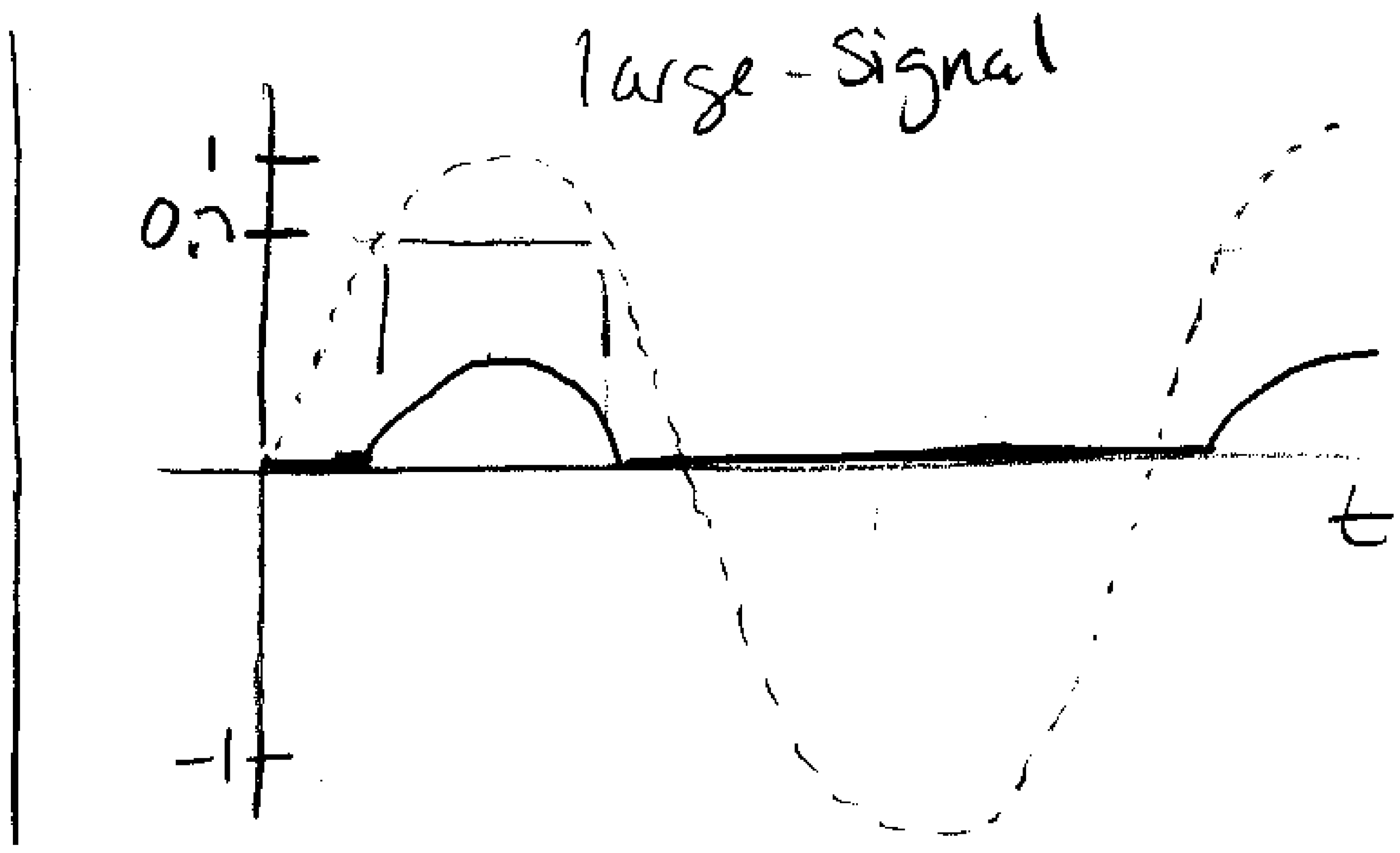
The key is to assume the diode is reverse biased (open circuit) and see if that causes a contradiction.

When sin(t) is negative, the diode can be reverse biased. The diode takes the voltage in this case.

a) ideal model: When sin(t) > 0, the diode cannot be reverse biased, and becomes a short circuit.

b) large-signal model; When sin(t) > 0.7, the diode cannot be reverse biased, and carries 0.7 V. It is reverse biased for sin(t) up to 0.7 V.

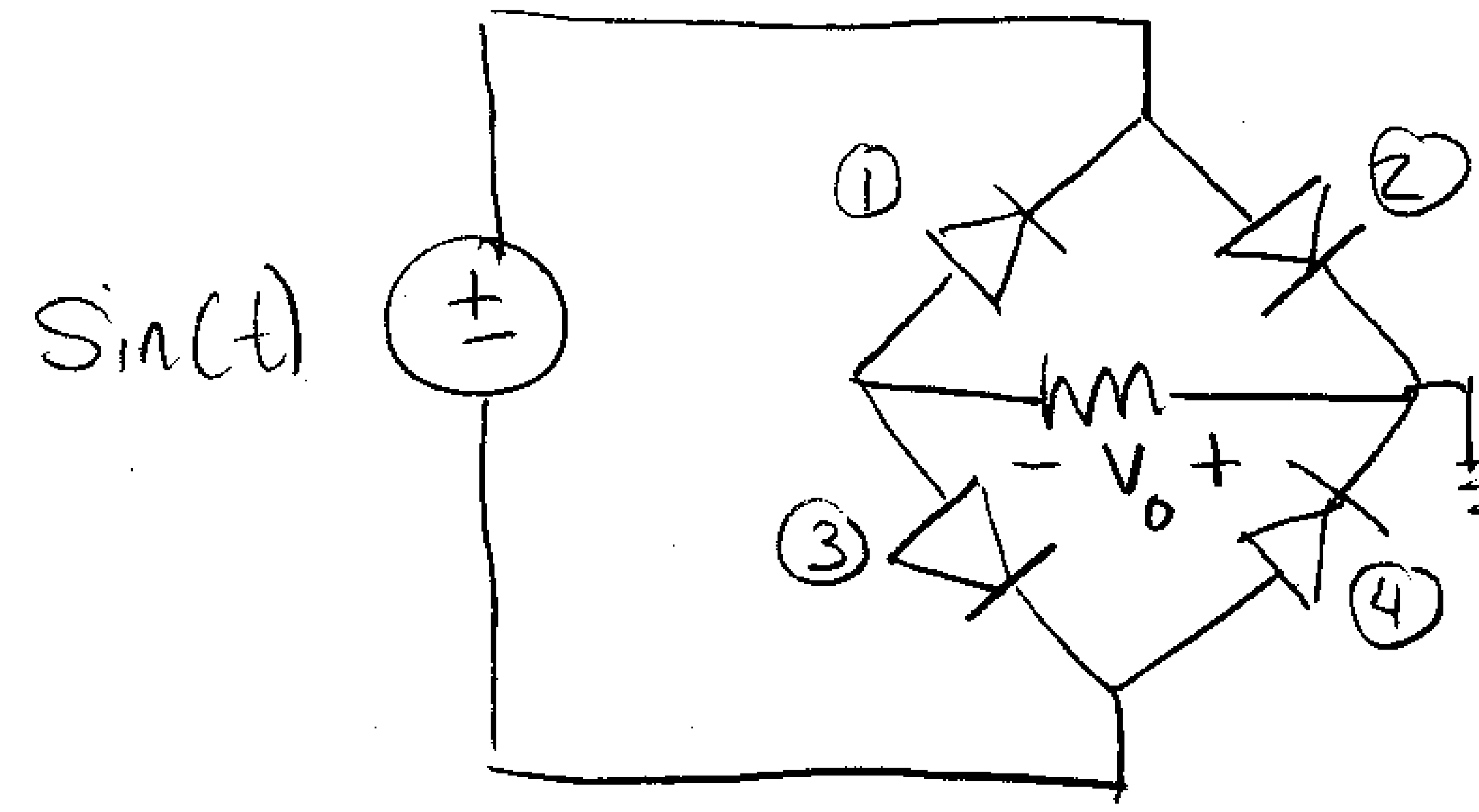




Vout is the part of Vin which is not across the diode.

10 points for each graph if correct
5 points for graph with minor error (upside down, etc)
0 points for graph with major error

Problem 3: 20 Points



ground does not matter here.

ideal model:

When sin(t) > 0, diodes 2 & 3 are forward biased (short circuit), and diodes 1 & 4 are reverse biased (open circuit). Current flows down thru diode 2, right to left thru resistor. Doing KVL thru the source, diode 2, resistor, & diode 3, we see the resistor takes all the input voltage.

When sin(t) < 0, diodes 1 & 4 are forward biased and diodes 2 & 3 are reverse biased. Current flows up through diode 4, right to left thru resistor, and thru diode 1. The resistor takes all the input voltage again, and the input voltage appears with the opposite polarity to Vout.

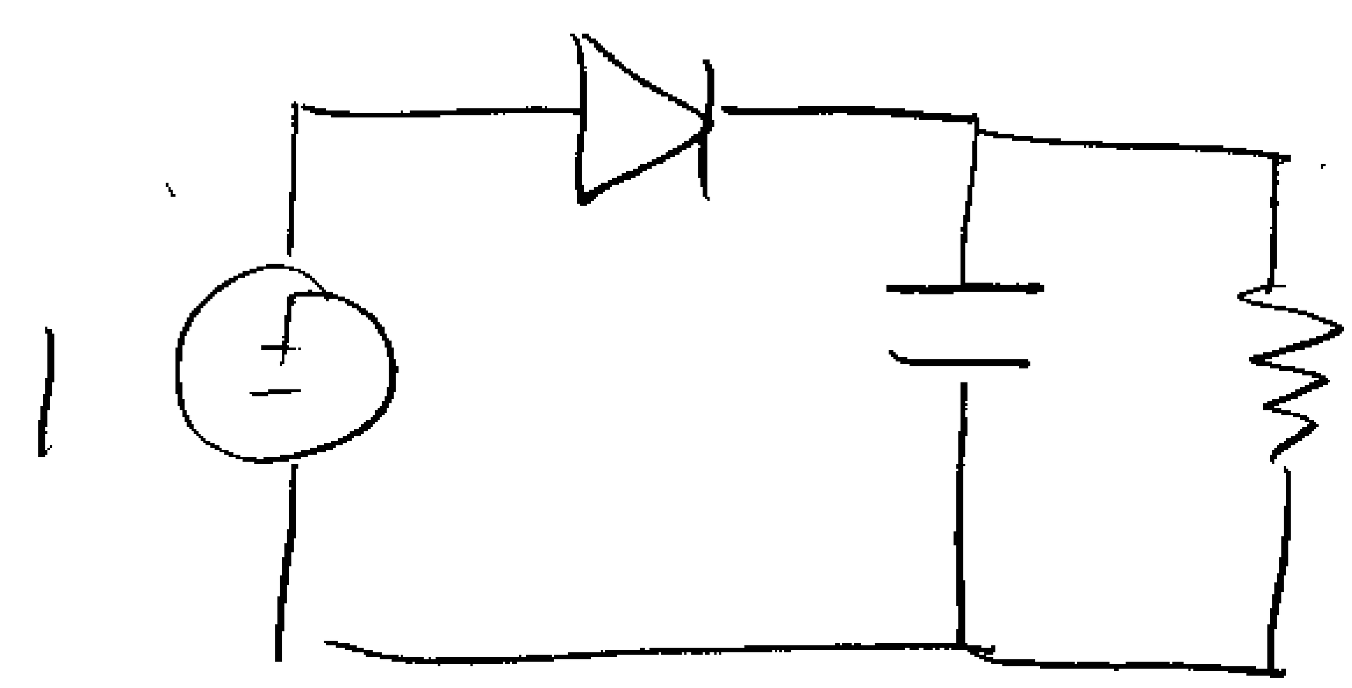
large-signal model:

In order to forward bias 2 diodes (we would need that for current to flow) we would need 1.4 V of input voltage. sin(t) never reaches 1.4, so no current ever flows. **V_o is always 0V.**

10 points for each correct graph
5 points for graph with minor errors (only 1 forward voltage considered, etc).

Problem 4: 20 Points

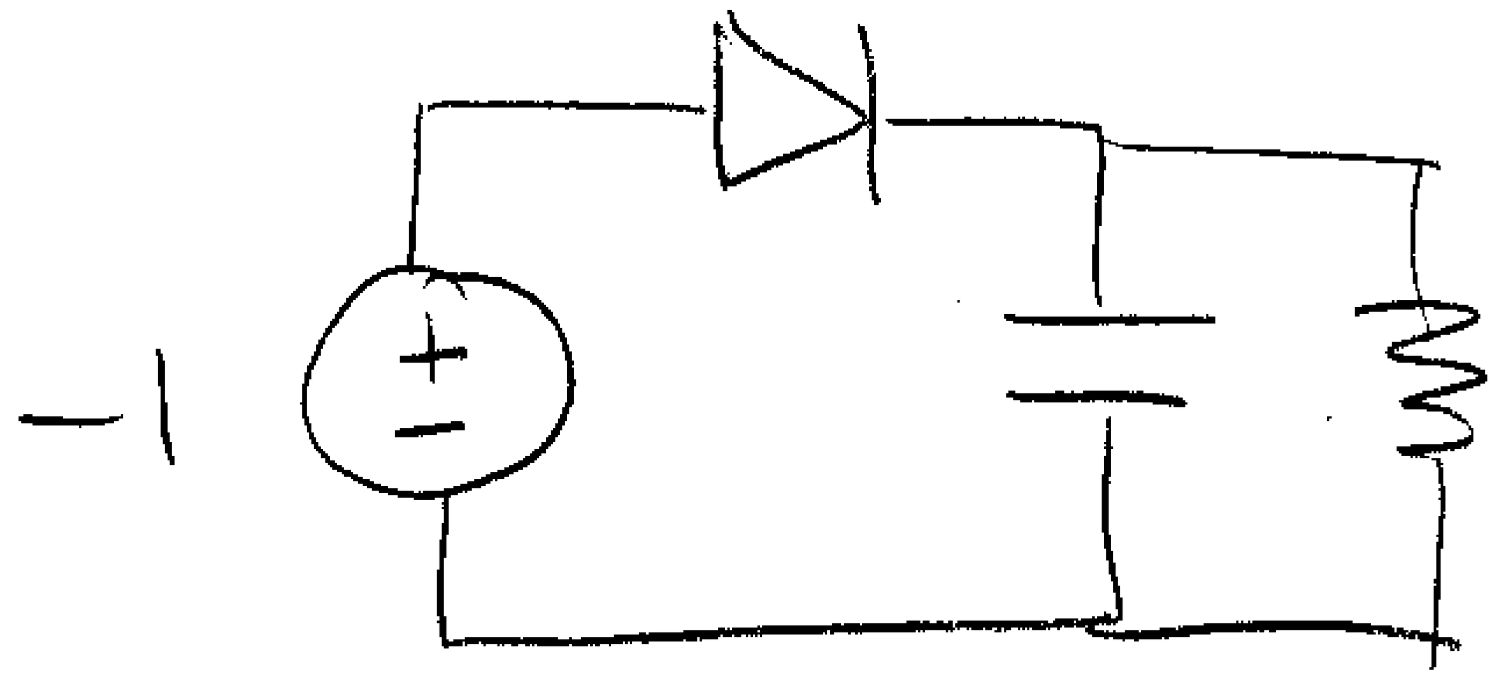
When the input voltage goes to 1,



the diode is forward biased. the capacitor will charge quickly, since the wire resistance & diode internal resistance are small. The capacitor will charge to $1 - V_F$ where V_F is the diode forward bias voltage.

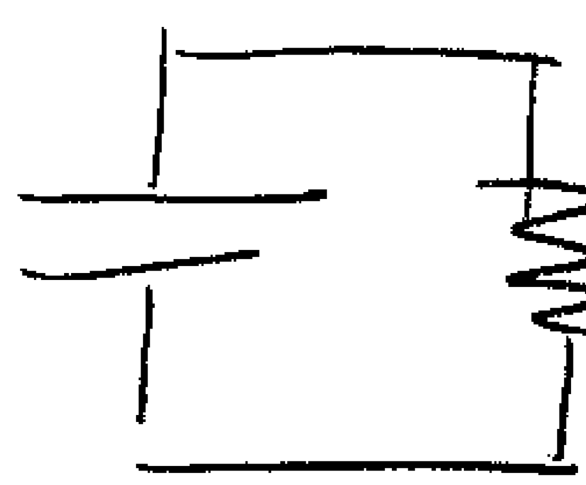
(6)

When the input goes to −1,



the diode is reverse biased (open circuit). The Capacitor will discharge,

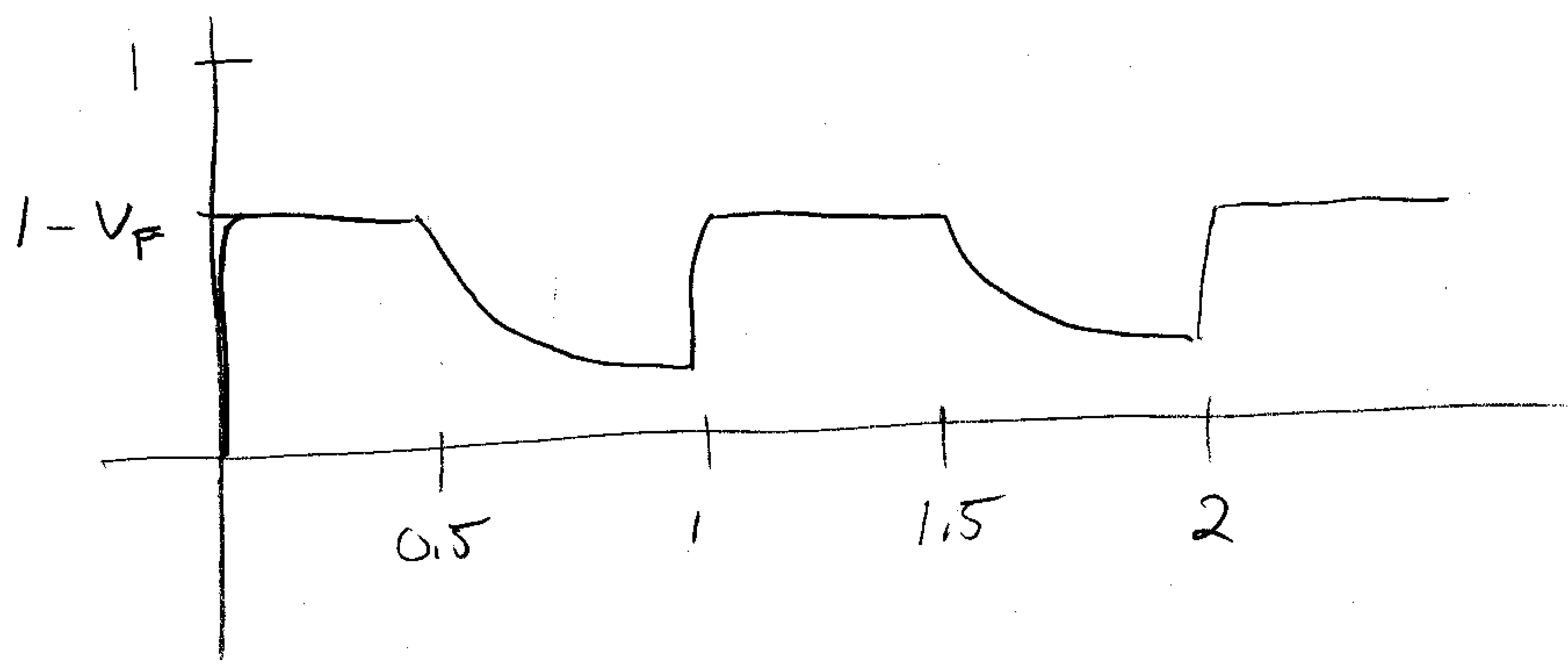
Since the effective circuit is



The time constant is

$RC = 10\,k\Omega \cdot 50\,\mu F = 0.5\,s$.

Thus, when the input voltage goes back to 1V (this occurs after 0.5 s), the output voltage will be 37% of the starting value.



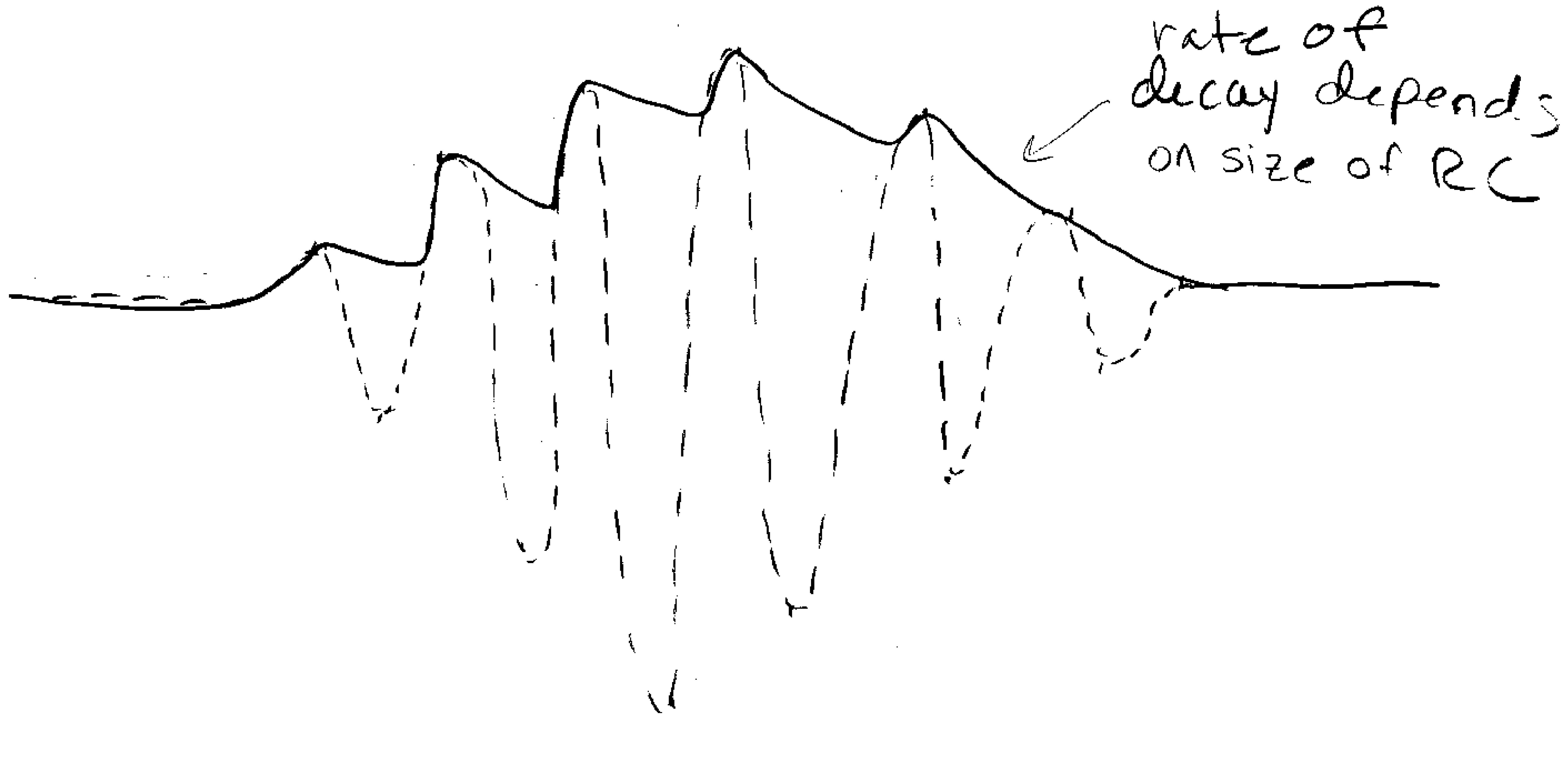
20 Points for correct graph
Students will have different V_F values depending on the model used – that is ok.

10 points for analysis with some minor errors, or for saying "not possible because capacitor voltage can't jump" and not completing analysis

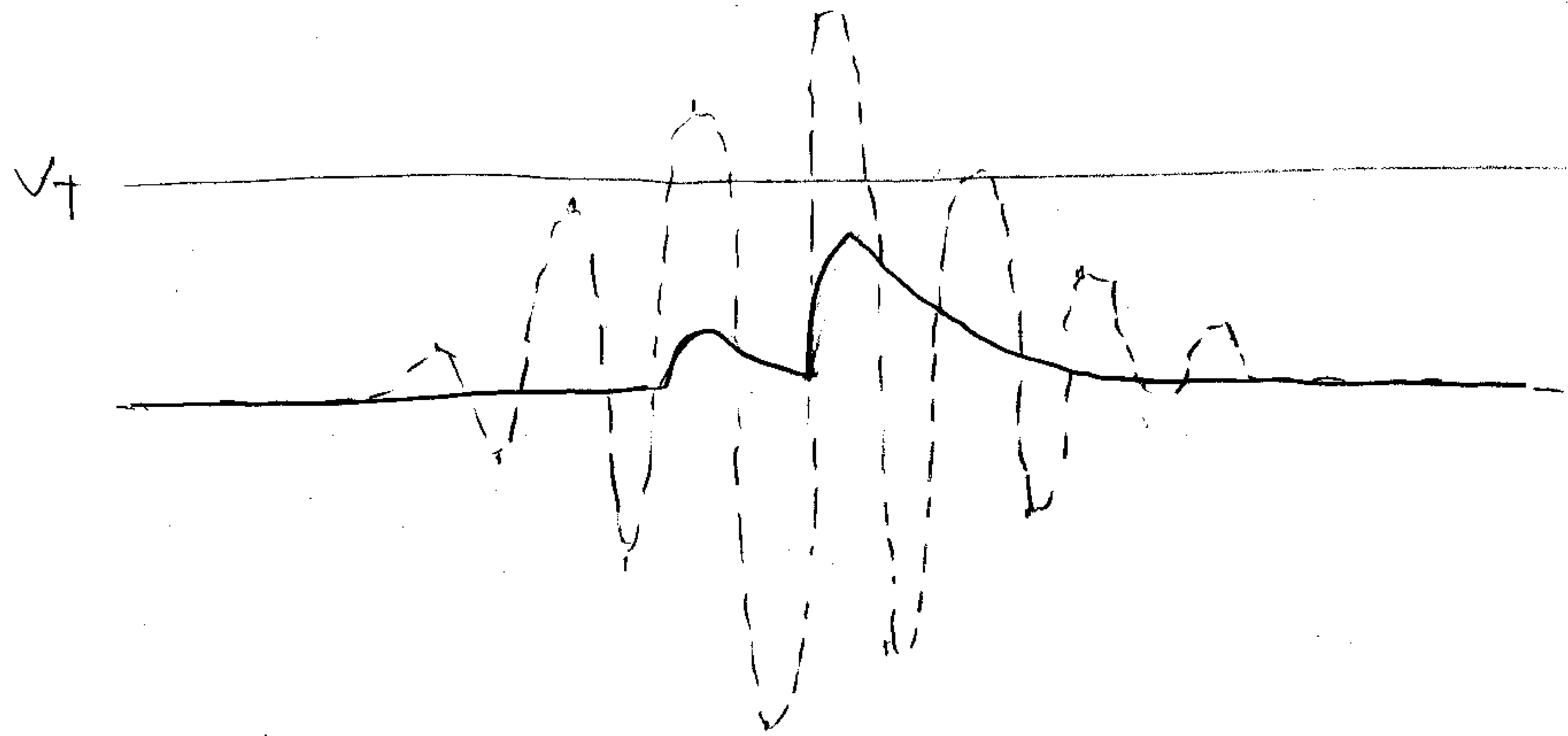
Problem 5: 20 points + 5 bonus

We now know the circuit charges quickly, discharges slowly, and it is important to remember that charging does not occur until the input voltage is greater than the diode forward voltage – and the capacitor charges to the difference.

a) So if there were no forward voltage drop:

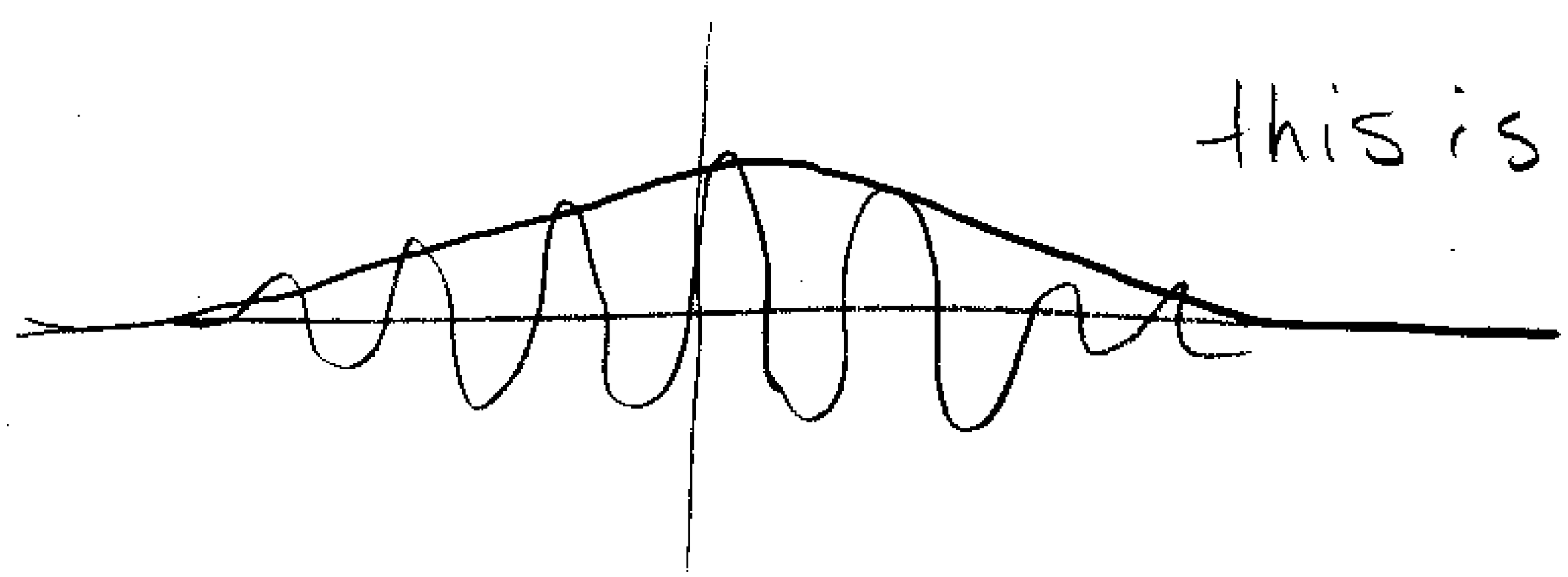


But if we have a forward voltage drop V_T,

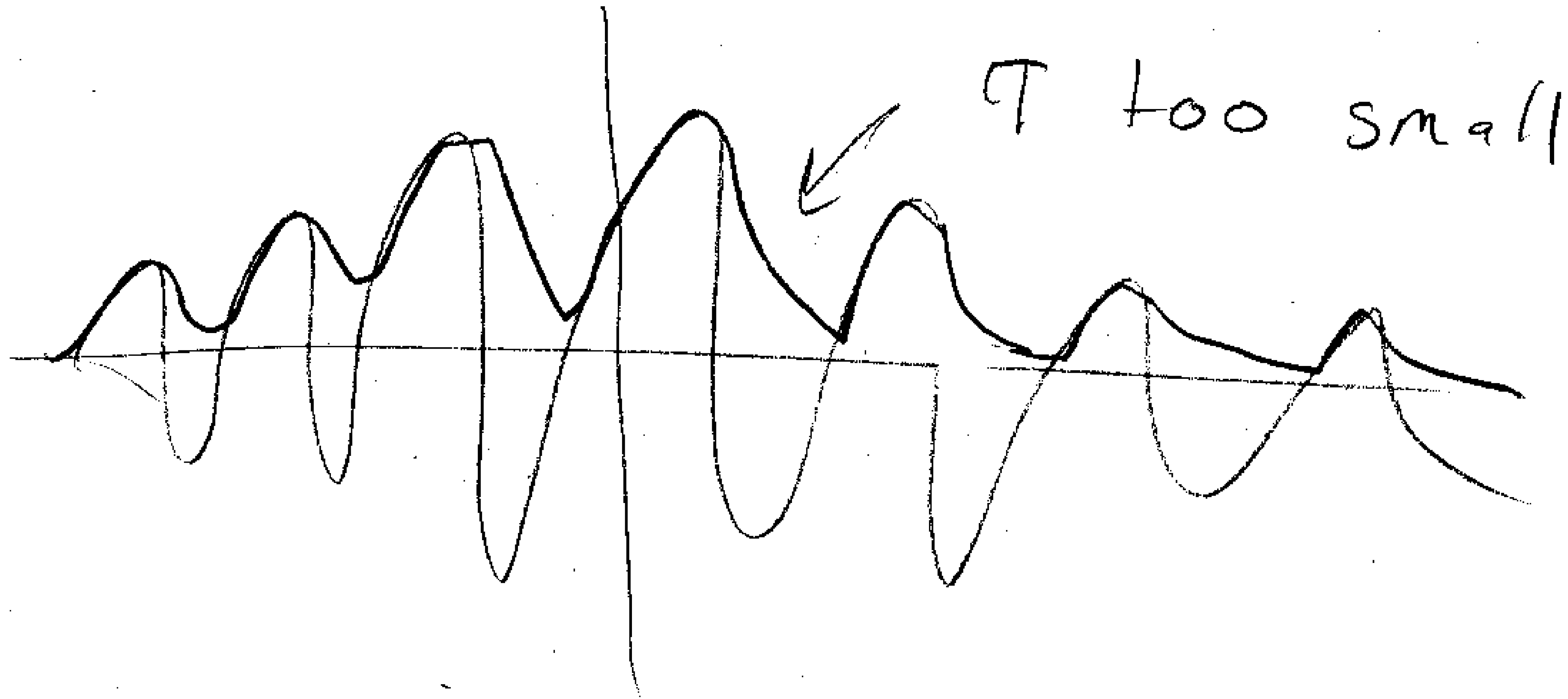


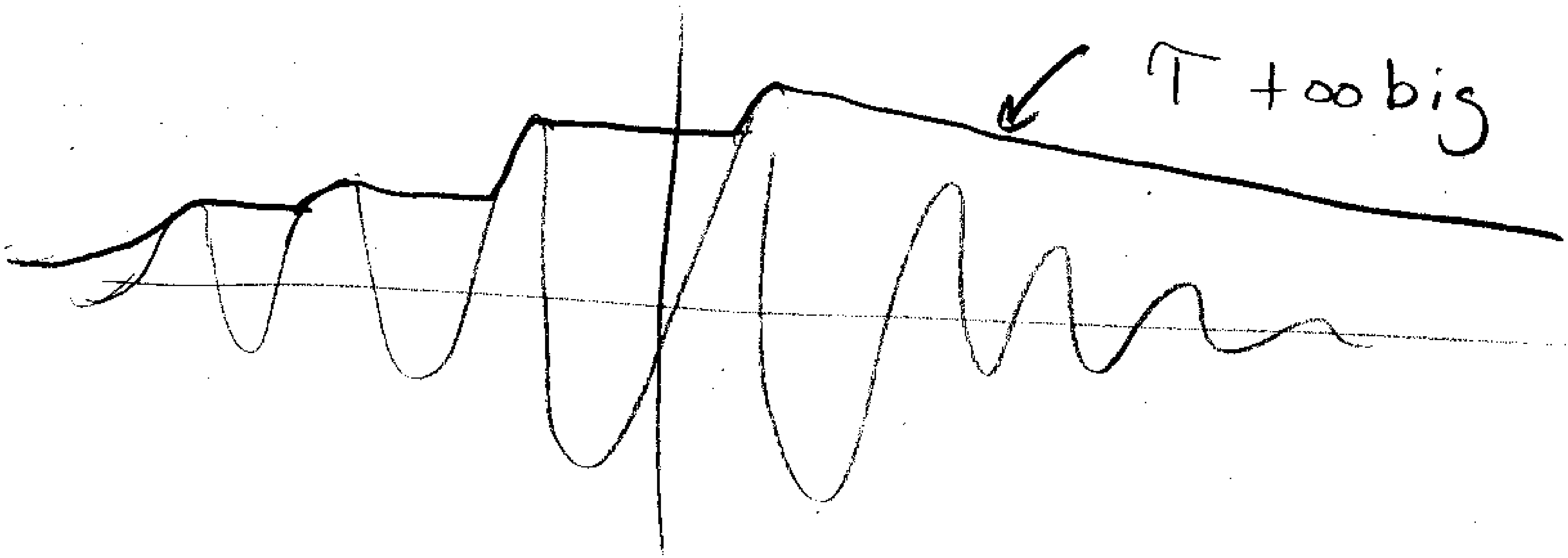
only 2 peaks here are big enough to affect V_{out}.

b) The time constant affects how quickly the output decays after a peak. If it is very small, decay is quick and the envelope will not be maintained (we want the following:)



If the time constant is too big, the output will not decrease when the peaks get smaller.





c) I showed in a) how the forward voltage drop affects the output: the input needs to be above the forward voltage drop to be noticed.

To fix: Use an amplifier to make the input signal bigger, or add a DC offset (not usually done in practice).

10 Points for a graph roughly similar to mine (may or may not have forward voltage considered). Be generous with partial credit.

10 Points for identifying the issues in part b). Generous partial credit.

5 Points for mentioning the forward voltage drop problem and giving one of the solutions.