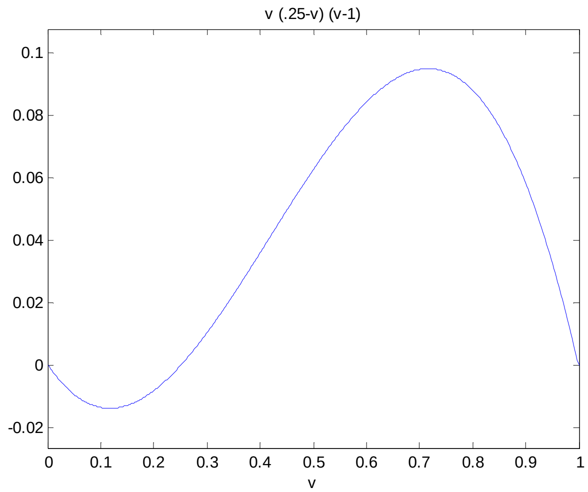
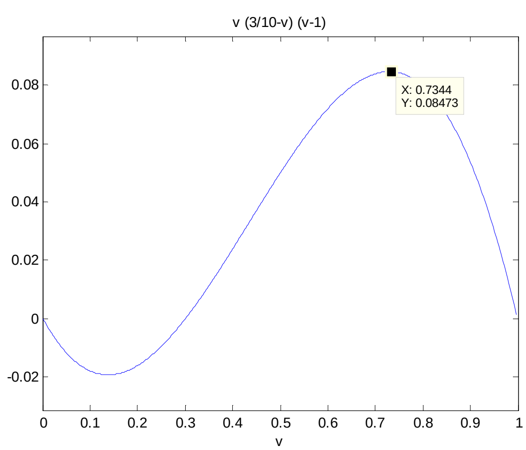
1.a.

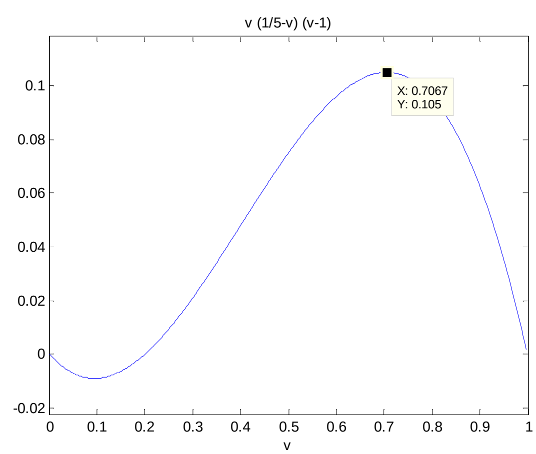


1.b. Since $f(.2) = -0.008$, we know that v will be decreasing at a rate of -0.008. As v decreases, we move to the left on the graph and see that the rate (f) stays negative, so v continues to decrease until it slows down to $v = 0$. If v starts at $v = 0.3$, then $f(.3)$ is positive, so v will be increasing. As v increases, we move to the right on the graph and see that v increases to $v = 1$.

1.c. Inspecting the graph, the maximum rate appears to occur at about $v = 0.718$ where the rate is $f(0.718) = 0.09476$.

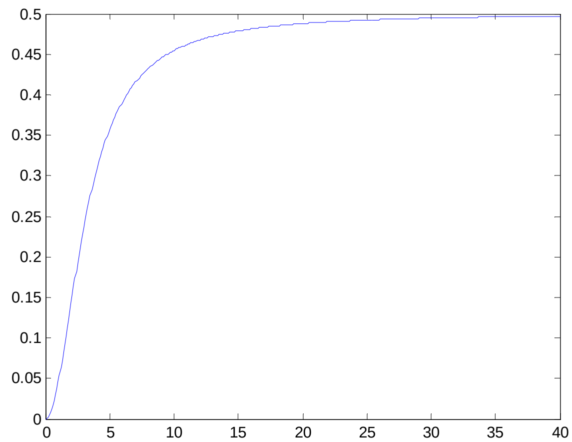
1.d. By plotting the graph of f for two different values of a on either side of 0.25, we can see what happens to the maximum rate. From the graphs below, we see that using $a = 0.3$ causes the maximum to shift down to about 0.08473 while using a value of $a = 0.2$ causes the maximum rate to shift up to about 0.105. Thus if we found that the actual rate was less than what we had before, we should make a larger.





1.e. The parameter a is the value of the potential at which the rate of change is zero. Any value of v bigger than a will have a positive rate, and the potential will move toward 1. Any value of v smaller than a will have a negative rate, and the potential will move toward zero.

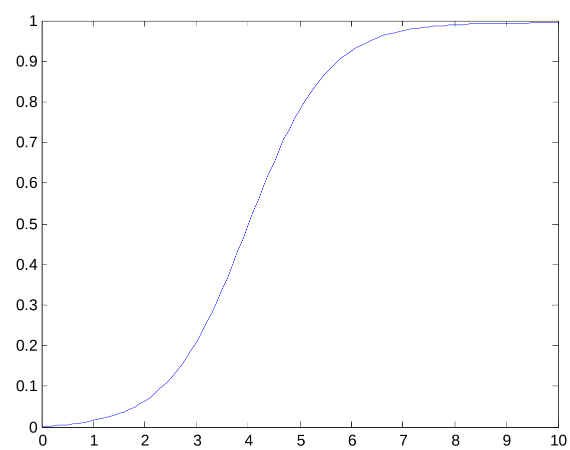
2.a.



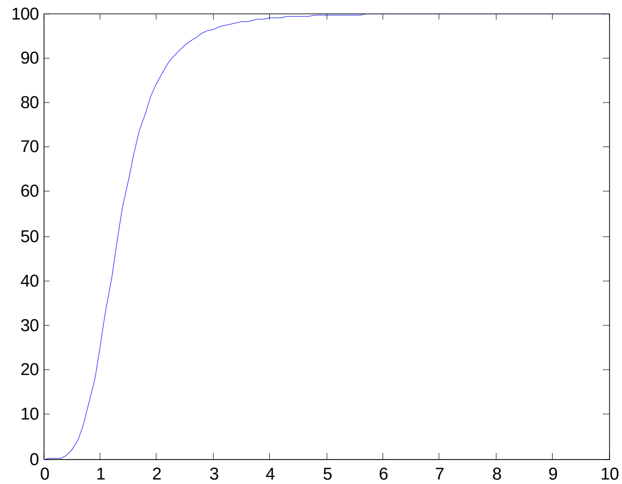
2.b. Using "hold on" in Matlab, we can graph the function for different values of *a*. Graphically, we see that the value of *a* is the limit of the function as $n \to \infty$. Within the context of the problem, we see that no matter how large *n* gets, the immune system never functions at a level above *a*.

2.c. Using "hold on" in Matlab, we graph the function for several values of *b*. For larger values of *b*, the the graph increases toward its limit more slowly (As we saw in part b, *J* tends toward a maximum as $n \to \infty$). In terms of the immune system, the larger *b* is, the more larvae we need for the immune system to function near its maximum.

3. *J* changes from increasing at an increasing rate to increasing at a decreasing rate when $z = 4$.



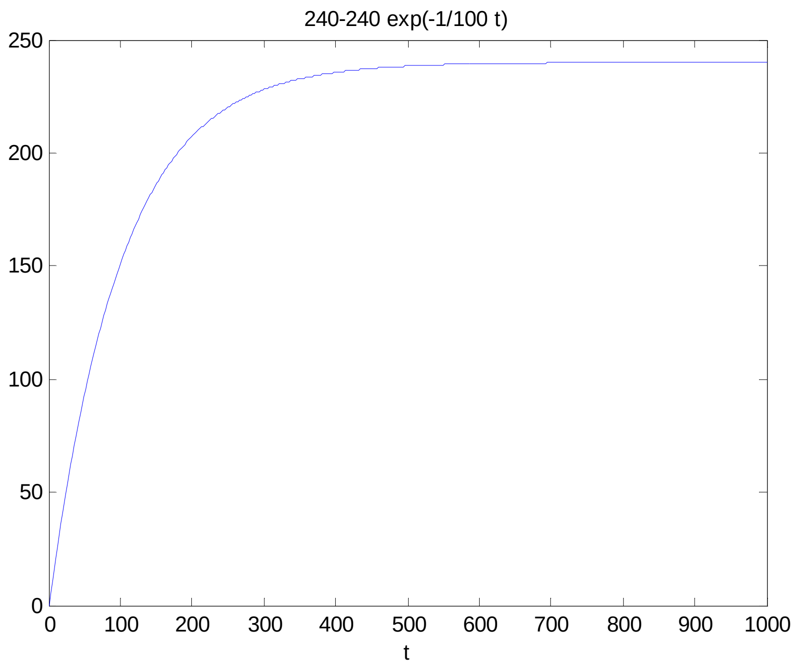
4.a.



4.b. Like in problem 2, the parameter *a* tells us the limit of the graph.

4.c. The degree of cooperativity is *n*. Using "hold on" in Matlab for several different values of *n*, we see that for larger values of *n*, the graph reaches the maximum quicker (for smaller values of *C*). In terms of the neurotransmitter, we release more of the chemical neurotransmitter with smaller amounts of intracellular calcium if *n* is larger.

5.a. Although it was omitted from the problem statement, the formula given measures time in micro-seconds (1 μs = 10^{-6} s) and the charge Q is measured in micro-coulombs (μC).



5.b. The capacitor tends toward a maximum of 240 μC and 90% of this is 216 μC. Looking at the graph, this occurs when t is about 230 μs, or 0.23 milliseconds (ms)

5.c. By plotting $Q(t)$ for 2 Ω and 10 Ω as shown below, we see that decreasing the resistance allows the capacitor to charge faster while increasing the resistance causes the capacitor to charge more slowly. It does not affect the limit, however which remains at 240 μC.