Exercise 1

a) E is the channel's reversal potential.
When $v = E$, no current flows through the channel (the current changes direction when v crosses E).

b) $$x(t) = x_0(E) + \left(x_0(v) - x_0(E)\right)\left(1 - e^{-t/\tau}\right)$$

c) We must find the p such that

$$\sqrt[p]{I_{ion}}$$

converges exponentially to the new asymptote.

In other words,

$$\log\left(\sqrt[p]{I_{ion}(\infty)} - \sqrt[p]{I_{ion}(t)}\right)$$

should look like a line.

d) We start by noting that, unless $x_0(v)$ is constrained to attain both 0 and 1, x_0 is ill-defined (one could, e.g., divide x_0 by 2, multiply g_0 by 2, and obtain the same identical observations).

Assuming $x_0(v) = 1$ somewhere we have

$$g_0 = \sup_{v} \frac{I_{ion}(\infty)}{(v - E)}$$

Exercise 2

a)

w - nullcline:

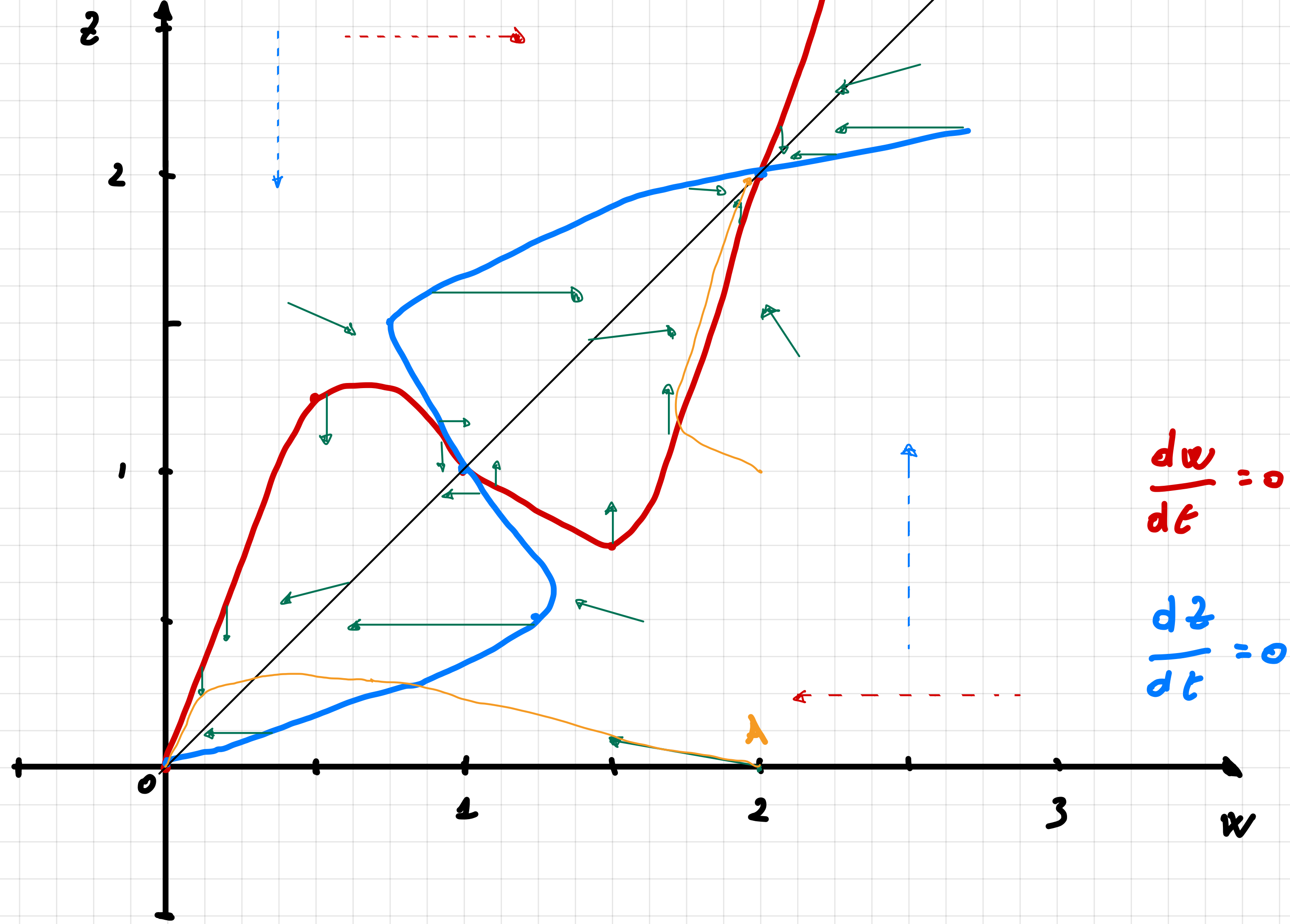
$$z = w - f(w)$$

z - nullcline:

$$w = z - f(z)$$

w	z
0	$0 - 0 = 0$
0.5	$0.5 + 2 \cdot 0.5 \cdot 0.5 \cdot 1.5 = 0.5 + 0.75 = 1.25$
1	$1 - 0 = 1$
1.5	$1.5 + 2 \cdot 1.5 (-0.5) 0.5 = 1.5 - 0.75 = 0.75$
2	$2 - 0 = 2$

z	w
0	0
0.5	1.25
1	1
1.5	0.75
2	2



b) At $(2, 0)$:

$$\frac{dw}{dt} = \gamma \left[0 - 2 + 0 \right] = -2\gamma = -0.5$$

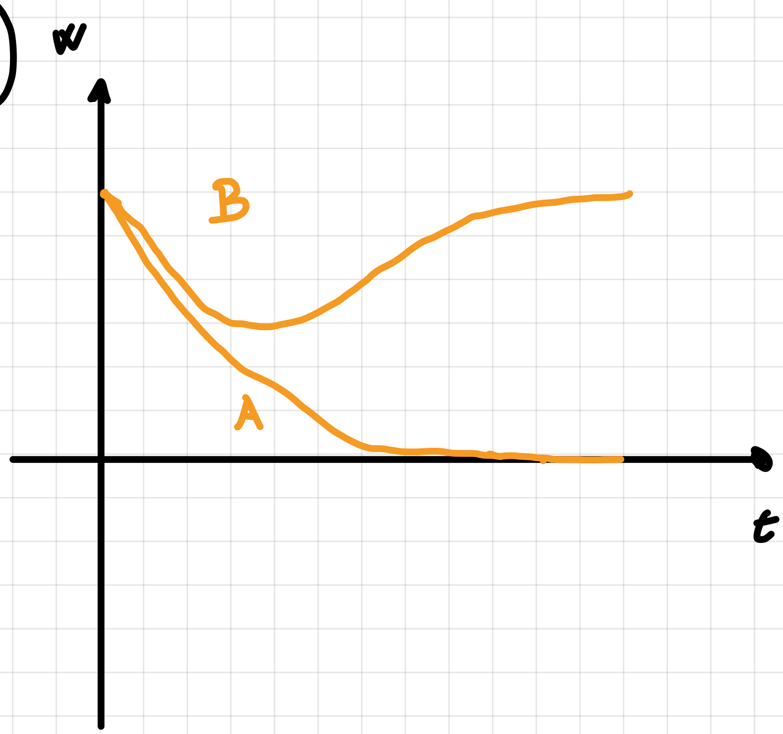
$$\frac{dz}{dt} = \varepsilon \left[0 - 0 + 2 \right] = 2\varepsilon = 0.1$$

c) (See plot!)

e) (See plot!)

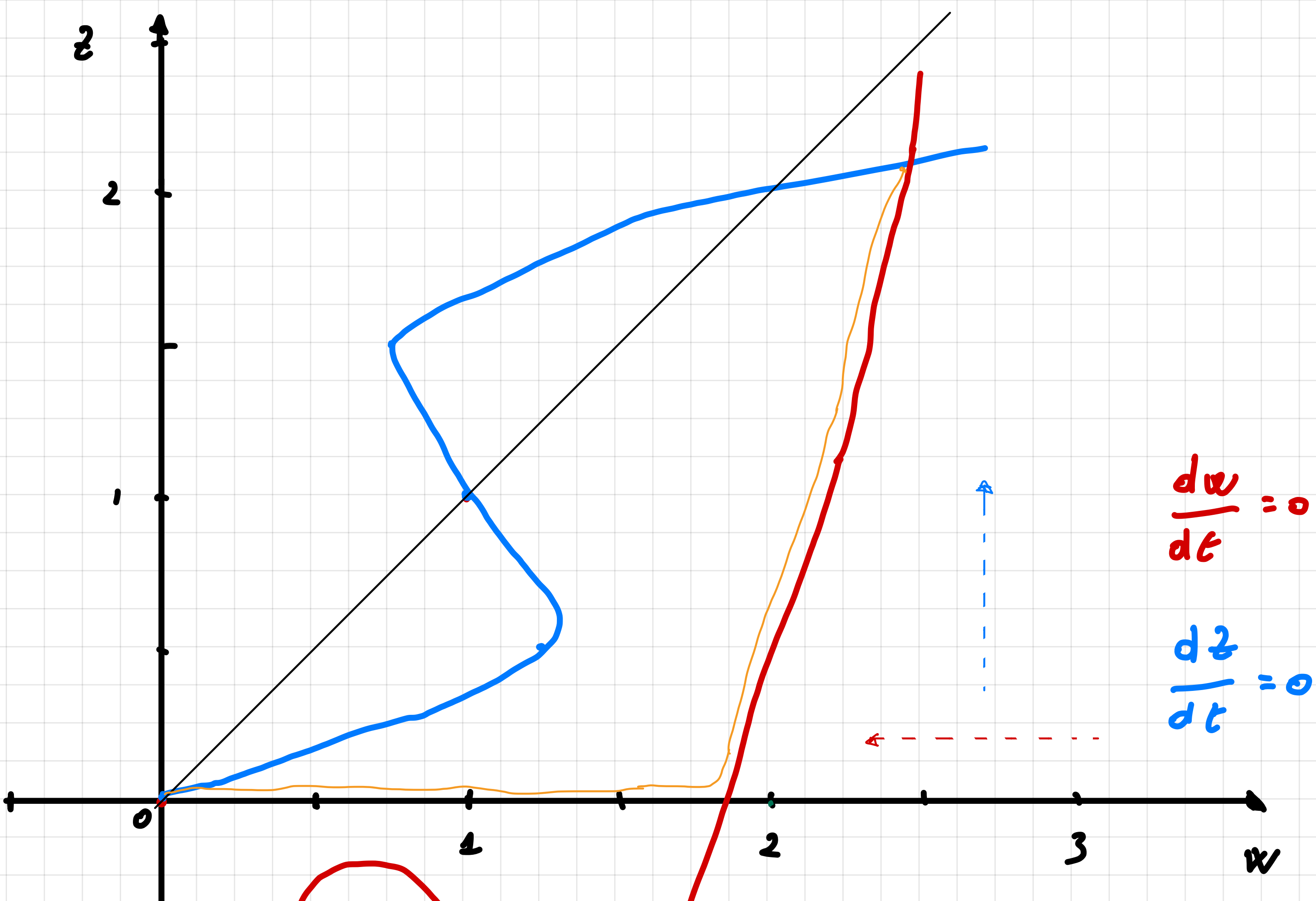
d) (See plot!)

f)



g) $\frac{dw}{dt} = 0 \iff z = w - f(w) - H$

dw/dt shifts down!



h) As we apply $H = 1.5$, the w-nullcline shifts down, leaving only one fixed point (the one with higher w).

As usual, I do not know what the biological interpretation is for this phenomenon.

i) (see plot!)