N Soumya [illegible]

Page No.: BE17B007

Date:

10/10/20

BT6270 Computational Neuroscience

Midsemester examination

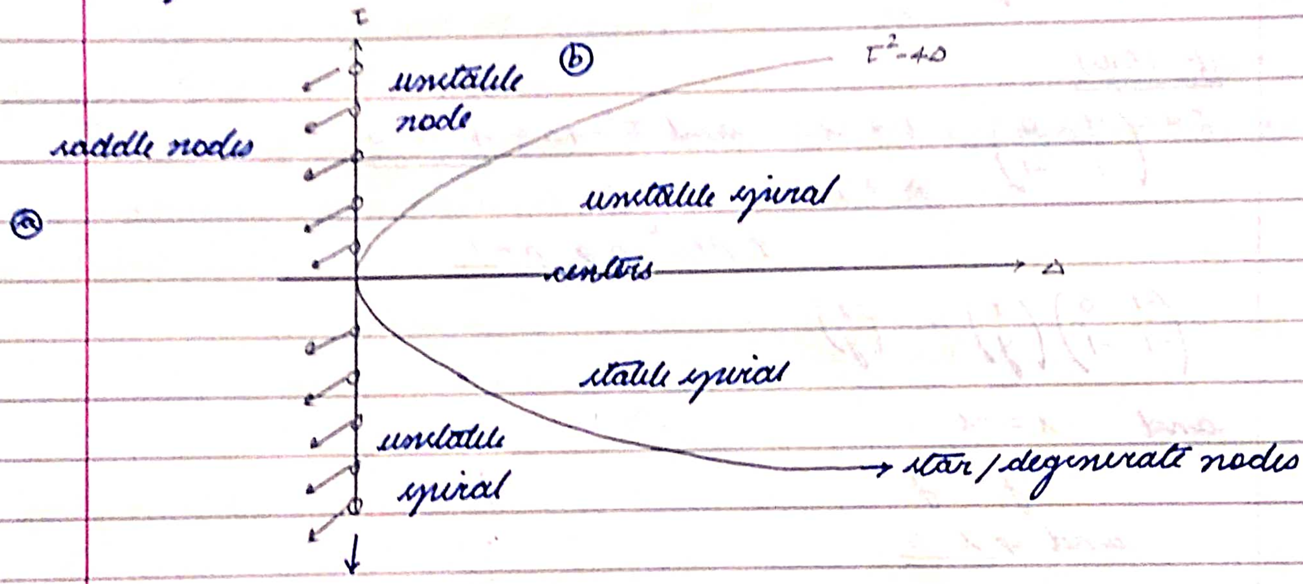
2)

(a) $\Delta < 0$, $\tau > 0$, $\tau^2 - 4\Delta > 0$

as $\Delta < 0$, the fixed point would be a saddle point

(b) $\Delta > 0$, $\tau > 0$, $\tau^2 - 4\Delta > 0$

the fixed point is an unstable node



3) $\dot{x} = -x + x^3$

$\dot{y} = -y - x$

XNC: $\dot{x} = 0 \Rightarrow x^3 - x = 0$

$\underline{\underline{x = 0 / x = -1 / x = 1}}$

$y =$ anything

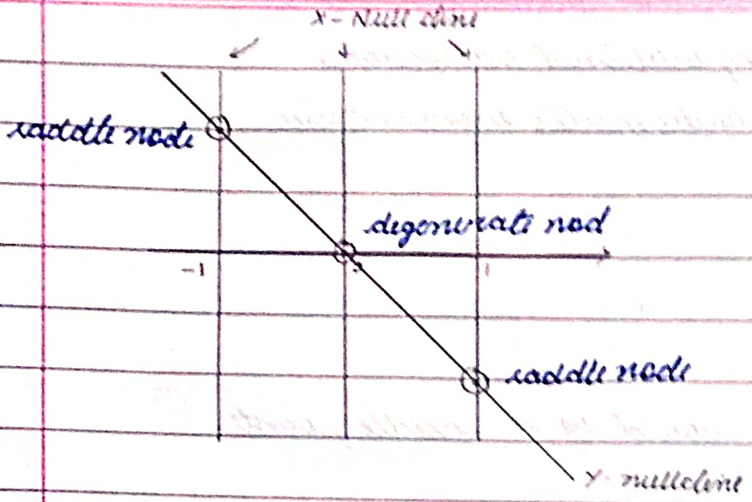
YNC: $x = -y \Rightarrow y = -x$

and

based on XNC values,

fixed points

$= \underline{\underline{(0,0), (1,-1), (-1,1)}}$



$$J = \begin{pmatrix} -1+3x^2 & 0 \\ -1 & -1 \end{pmatrix}$$

- <u>at (0,0)</u>

$$J = \begin{pmatrix} -1 & 0 \\ -1 & -1 \end{pmatrix} \qquad \tau = -2 \qquad \text{and } \tau^2 - 4\Delta = \underline{4-4=0}$$

$$\Delta = 1$$

$$\Rightarrow (\lambda+1)^2 = 0 \Rightarrow \underline{\lambda = -1}$$

$$\begin{pmatrix} -1 & 0 \\ -1 & -1 \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix} = -\begin{pmatrix} x \\ y \end{pmatrix}$$

and $-x = -x$

$-x-y = -y$

and $\Rightarrow \underline{x=0}$

eigen vector = $\underline{\begin{pmatrix} 0 \\ 1 \end{pmatrix}}$

$\Rightarrow$ $\boxed{\text{degenerate node}}$

- <u>at (1,-1) and (-1,1)</u>

$$J = \begin{pmatrix} -1+3x^2 & 0 \\ -1 & -1 \end{pmatrix} = \begin{pmatrix} 2 & 0 \\ -1 & -1 \end{pmatrix} \qquad \tau = 1 \qquad \text{and } \Delta < 0$$

$$\Delta = -2 \qquad \Rightarrow \boxed{\text{saddle node}}$$

6)

site of summation in a neuron	axon hillock
glutamate neurotransmitter	NMDA receptor
myelin sheath	increased conduction velocity
activation gate	opens with increased membrane potential
Metabotropic receptors	second messenger signalling

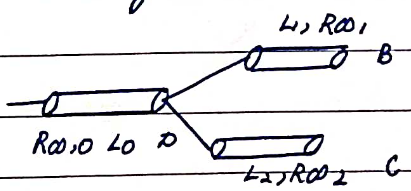
(A-4); (B-1); (C-5); (D-2); (E-3)

5)

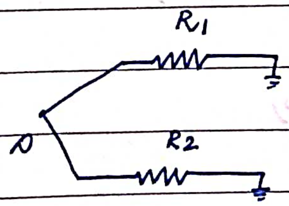
Arrival of action potential on presynaptic terminal
Entry of Ca^{+2} ions into the presynaptic terminal
Release of neurotransmitters
Binding of neurotransmitters with receptors on postsynaptic terminal
Opening of ion channels on the post synaptic terminal
EPSP / IPSP

$c \rightarrow a \rightarrow f \rightarrow e \rightarrow b \rightarrow d$

4) considering sealed end



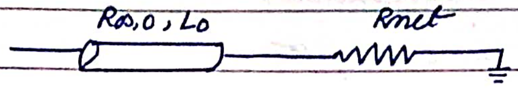
Resistance of B (sealed end) $= R_{\infty 1} \coth(L_1) = R_1$
C (sealed end) $= R_{\infty 2} \coth(L_2) = R_2$



parallel

$$\Rightarrow R_{net} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} = \frac{R_{\infty 1} R_{\infty 2} \coth(L_1)\coth(L_2)}{R_{\infty 1}\coth(L_1) + R_{\infty 2}\coth(L_2)}$$

Hence, the network becomes



Hence, $R_{net} = R_L$ of the main cable

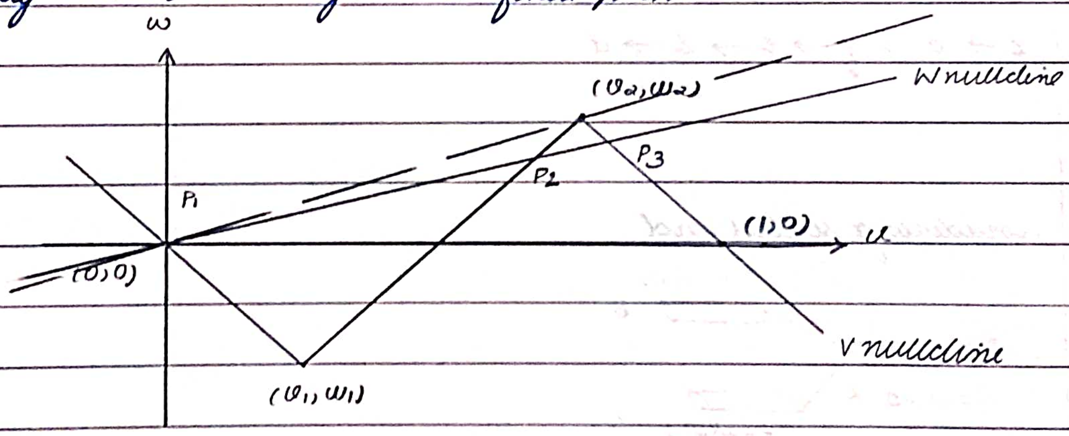
$\Rightarrow$ Loading resistance of main cable =

$$\boxed{R_L = \frac{R_{\infty 1} R_{\infty 2} \coth(L_1) \coth(L_2)}{R_{\infty 1} \coth(L_1) + R_{\infty 2} \coth(L_2)}}$$

2) $\dot{u} = f(u) - w + I_a$

$\dot{w} = bu - w$

Bistability : 2 stable ~~and origin states~~ fixed points



$$f(u) = \begin{cases} -w + \dfrac{w_1 u}{u_1} & u < u_1 \\[2ex] -w + \left(\dfrac{w_2 - w_1}{u_2 - u_1}\right) u + w_1 u_2 - w_2 u_1 & u \in [u_1, u_2) \\[2ex] -w + \dfrac{w_2 u}{u_2 - 1} - \dfrac{w_2 u}{u_2 - 1} & u \in [u_2, \infty) \end{cases}$$

for the "w nullcline" to intersect twice with the "v nullcline" the slope of w nullcline should be less than (w_2/v_2)

if $b = w_2/v_2$, WNC intersects VNC exactly at (v_2, w_2)

$\Rightarrow \underline{b < w_2/v_2}$

and $\boxed{b \in (0, w_2/v_2)}$

stability of points:

- $\underline{P_1 = (0,0)}$

and $J = \begin{pmatrix} f'(0) & -1 \\ b & -1 \end{pmatrix}$

$= \begin{pmatrix} w_1/v_1 & -1 \\ b & -1 \end{pmatrix}$

and $\tau = \dfrac{w_1}{v_1} - 1$ $\qquad \Delta = \dfrac{-w_1}{v_1} + b$

$w_1 < 0$; $v_1 > 0$ $\qquad \underline{\underline{\Delta > 0}}$

$\Rightarrow \underline{\tau < 0}$

stable

- P_2 :

$J = \begin{pmatrix} \left(\dfrac{w_2 - w_1}{v_2 - v_1}\right) & -1 \\ b & -1 \end{pmatrix}$

and $\tau = \dfrac{w_2 - w_1}{v_2 - v_1} - 1$

saddle $\Rightarrow$ $\Delta < 0$

$\Delta = b - \dfrac{(w_2 - w_1)}{(v_2 - v_1)}$ $\qquad \Rightarrow b < \underline{\underline{\dfrac{(w_2 - w_1)}{(v_2 - v_1)}}}$

P3

$$J = \begin{pmatrix} \frac{w_2}{u_2 - 1} & -1 \\ b & -1 \end{pmatrix}$$

$\tau = \frac{w_2}{u_2 - 1} - 1$ $\Delta = \frac{-w_2}{u_2 - 1} + b$

and $\frac{w_2}{u_2 - 1} < 0$ as $u_2 < 1$ $\underline{\underline{\Delta > 0}}$

and $\underline{\underline{\tau < 0}}$ $\rightarrow$ stable