Basic Tracer Kinetic Concepts

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Steady state of the system

- i.e. the physiologic parameter is constant during the measurement
- Examples: flow (ml/s), perfusion (ml/g/s), CMRO2 (mmol/g/s), glucose uptake (mmol/g/s)
- Consider: duration of the measurement in relation to the a spontaneous change of the parameter or timing of a pertubation of the parameter

Steady state of the system

- Exceptions: the physiologic parameter oscillates relative fast compared to the duration of the measurement
- Note: steady state not necessary implies that fluxes or concentration is constant in time

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Tracers and indicators

- Tracers: labelled substances, behaves physically and chemically like the modersubstances;
- e.g. $H_2{}^{15}O$, $^{17}O_2$, ^{57}Co-vitB12, ^{131}I-thyroxin
- Or behaves nearly like the modersubstance
- e.g. ^{18}FDG , ^{125}I-albumin, ^{131}I-insulin

- Indicators: not necessary related to a modersubstance
- e.g. contrast agents – x-rays – SPECT (99mTc-HMPAO, 99mTc-sestamibi), - MRI (Gd-DTPA, Mn-DPDP)
- Law of conservation: mass balance
- Note: tracers can be intravascular,extracellular, free difussible, bound to a receptor or behave in a more specific way

Should not disturb the system we are studying

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- **Note:**

tracers can be intravascular, extracellular, free difussible, or behave in a more specific way

Intravascular	Radioactive microsphere Radioactive erytrocytes Radioactiv albumin
Ekstravascular	^{51}Cr-EDTA sucrose inulin Gd-DTPA (MR)
Freely diffusible	^{133}Xe heat NO H_2 $^{15}H_20$ ^{17}O
Specials	^{99m}Tc-HMPAO (brain) ^{99m}Tc-sestamibi (heart) ^{18}Fluor-DeoxyGlucose

Linearity of a system

RF(t) : response function or more correctly

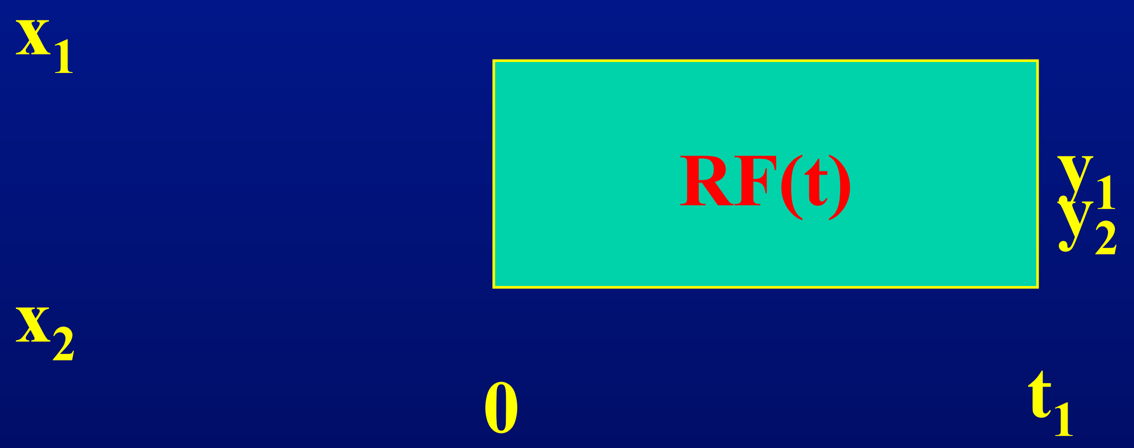
: The impulse response function

Linearity of a system

$$x \xrightarrow{RF(t)} y$$

scaling $$a\,x \xrightarrow{RF(t)} a\,y$$

Linearity of a system



$$x_1 + x_2 \xrightarrow{RF(t)} y_1 + y_2$$

Principle of superposition

Examples

3
3 +4
4

x 2

6
14
8

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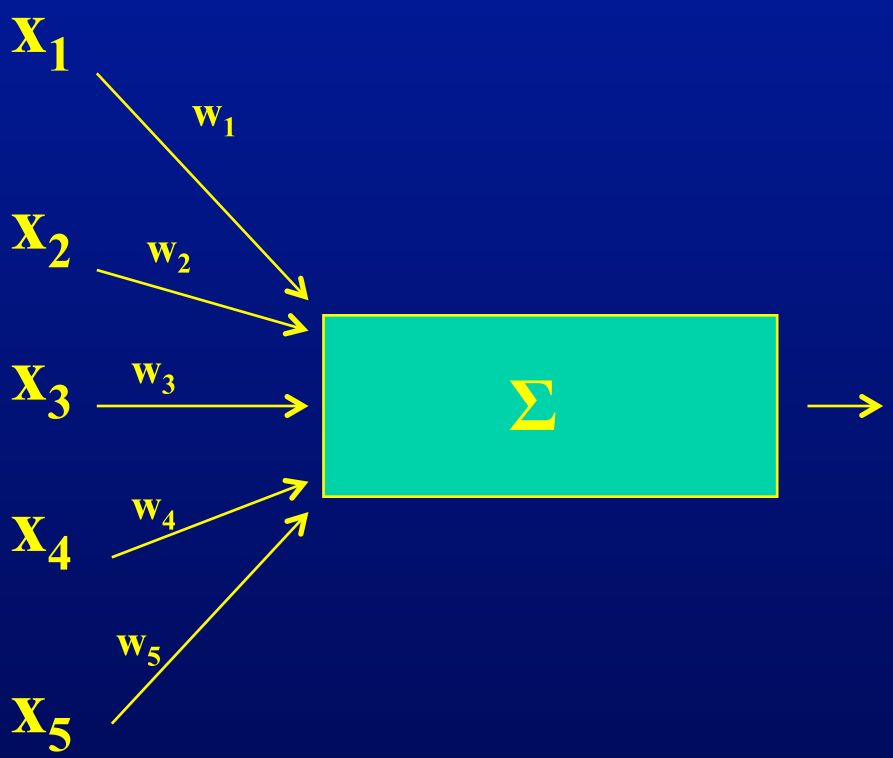
Examples



$x_1w_1+x_2w_2+x_3w_3$
$+x_4w_4+x_5w_5$

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Examples

3

3 +4

4

log

log3

log(3+4)

log4

$$\log 3 + \log 4 \neq \log(3+4)$$

Linearity of a system

RF(t)

$$\mathbf{a\,x_1 + b\,x_2} \longrightarrow \mathbf{a\,y_1 + b\,y_2}$$

Time invariance of a system

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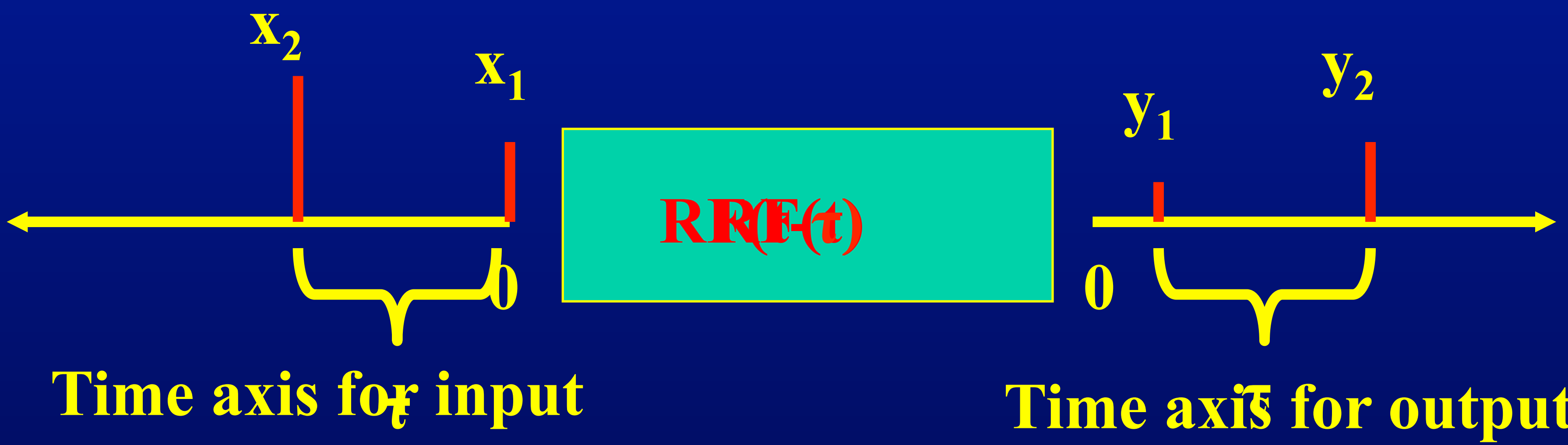
Specification of time



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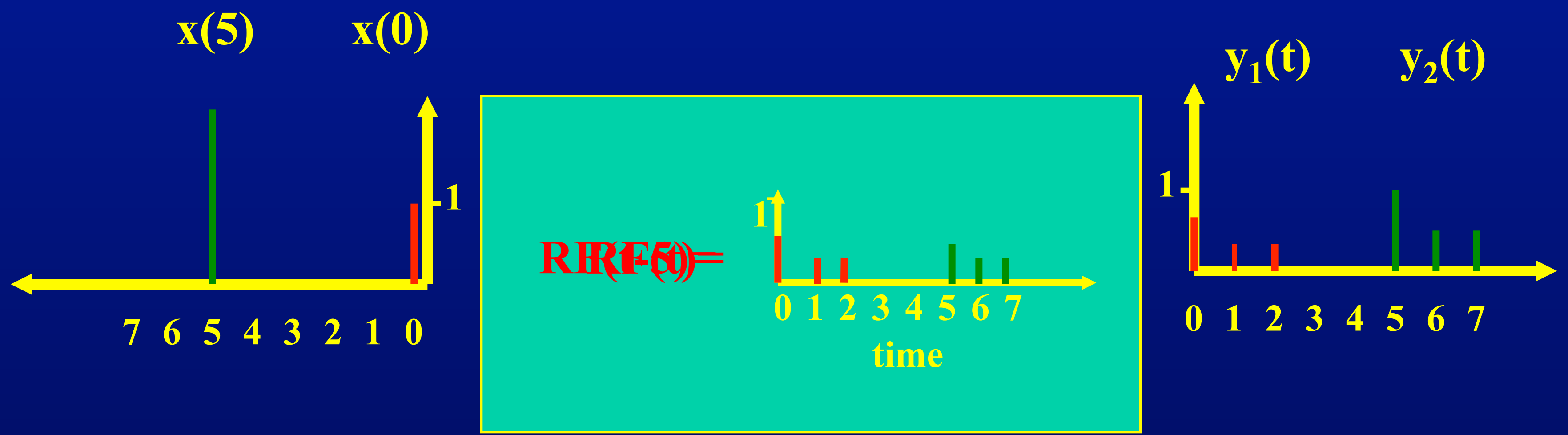
Example



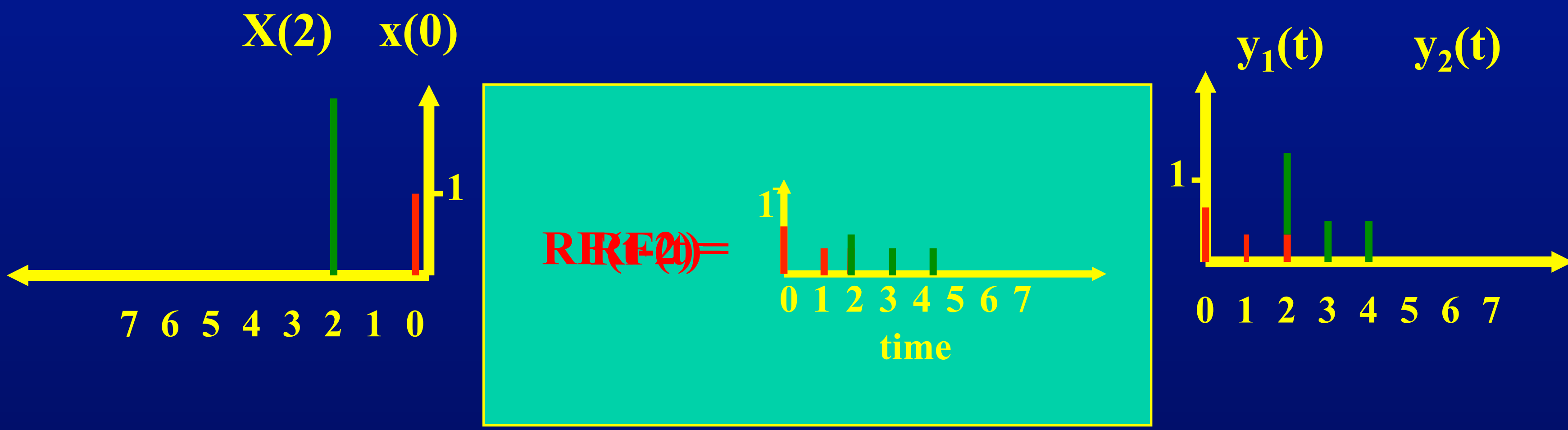
$y_1(t) = x(0) \cdot RF(t)$

$y_2(t) = x(5) \cdot RF(t)$

$y_2(t) = x(5) \cdot RF(t-5)$

Does not work !!!

Example



$y_1(t) = x(0) \cdot RF(t)$

$y_2(t) = x(2) \cdot RF(t)$

$y_2(t) = x(2) \cdot RF(t-2)$

Does not work !!!

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Causality of a system

Output is only observed after an input has enter the system

Causality of a system

Output is only observed after an input has enter the system

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Can a biological system
behave like such a system?
Describe in words how a biological
system could interact with a
instantaneous tracer input
!

Linearity of a imaging system?

!