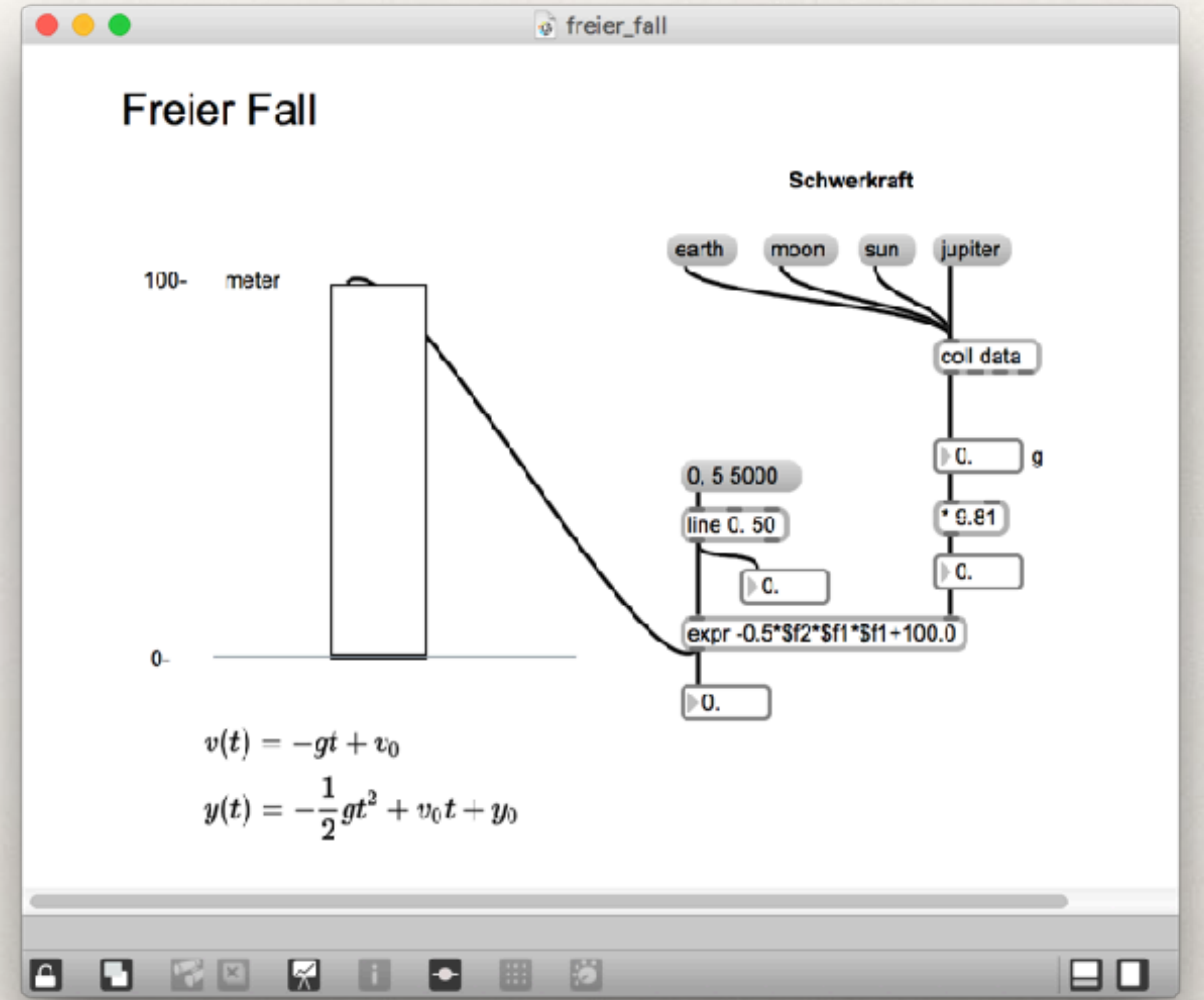
Software 2 WS 2016 #5

Chikashi Miyama

Physical Modeling

- Physikalische Simulation mit Computer?

Experiment mit Max



Nature of Code

Daniel Shiffman

http://natureofcode.com

Physikalische Simulation
mit Processing

kostenlos

Mode

- Was ist **Mode**?

Mode

- Was ist **Mode**?

mode | məʊd |

noun

1 a way or manner in which something occurs or is experienced, expressed, or done: *his preferred mode of travel was a kayak.*

- an option allowing a change in the method of operation of a device, especially a camera: *a camcorder **in automatic mode**.*
- *Computing* a way of operating or using a system: *some computers provide several so-called processor modes.*
- *Physics* any of the distinct kinds or patterns of vibration of an oscillating system.
- *Logic* the character of a modal proposition (whether necessary, contingent, possible, or impossible).
- *Logic & Grammar* another term for MOOD[2].

2 a fashion or style in clothes, art, literature, etc.: *in the Seventies the mode for active wear took hold.*

3 *Statistics* the value that occurs most frequently in a given set of data.

4 *Music* a set of musical notes forming a scale and from which melodies and harmonies are constructed.

The modes of plainsong and later Western music (including the usual major and minor scales) correspond to the diatonic scales played on the white notes of a piano. They are named arbitrarily after ancient Greek modes: Ionian (or major), Dorian, Phrygian, Lydian, Mixolydian, Aeolian, and Locrian.

4.1 A Simple Mechanical System

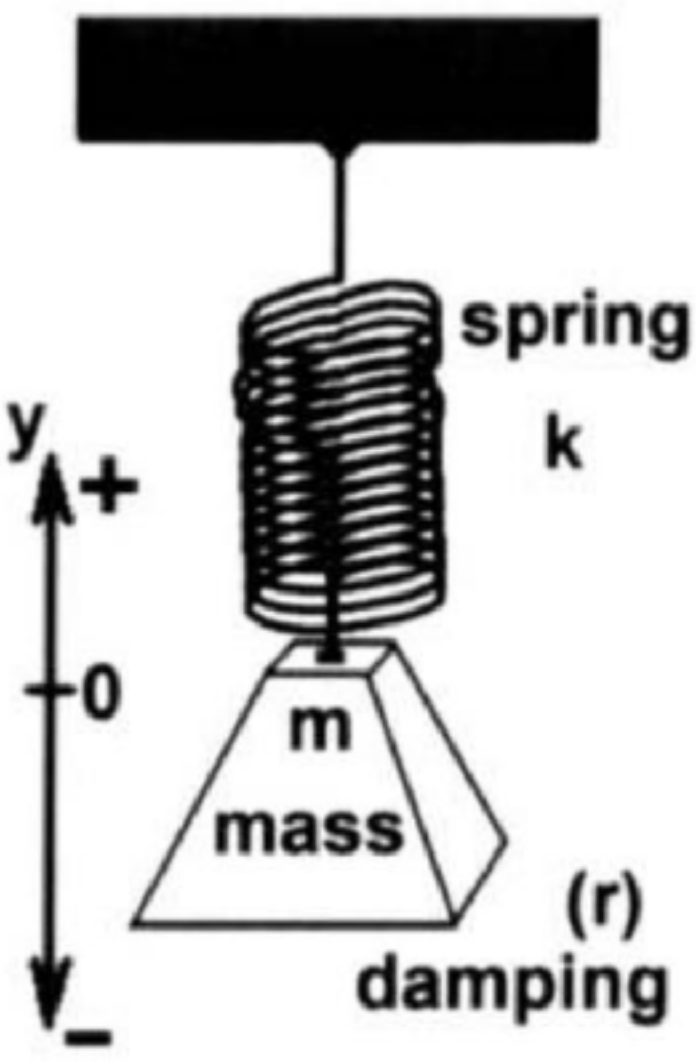


Figure 4.1. Mass/spring system.

m = Masse

y = Federkraft

r = Verlust

k = Kraft

4.1 A Simple Mechanical System

$$-ky - mg - rv = F$$

F = Force (Kraft)

k = Kraft
y = Federkraft

in negative
Richtung

m = Masse
g = Gravity
(Schwerkraft)

r = Verlust
v = Velocity
(Geschwindigkeit)

4.1 A Simple Mechanical System

2. Newtonsches Gesetz

Das 2. Newtonsche Gesetz stellt einen Zusammenhang zwischen den physikalischen Größen Kraft, Beschleunigung und Masse her. Die Formel sieht wie folgt aus:

- **F = m · a**
- "F" ist die Kraft in Newton [N]
- "m" ist die Masse des Körpers in Kilogramm [kg]
- "a" ist die Beschleunigung in Meter pro Sekunde-Quadrat [m/s^2]

Weitere Informationen zum 2. Newtonschen Gesetz erfahrt ihr in einem separatem Artikel. Weiter zum Artikel Kraft / Kräfte nach Newton.

4.1 A Simple Mechanical System

$$-ky - mg - rv = ma$$

m = Masse
a = Acceleration
(Beschleunigung)

k = Kraft
y = Federkraft

in negative
Richtung

m = Masse
g = Gravity
(Schwerkraft)

r = Verlust
v = Velocity
(Geschwindigkeit)

4.1 A Simple Mechanical System

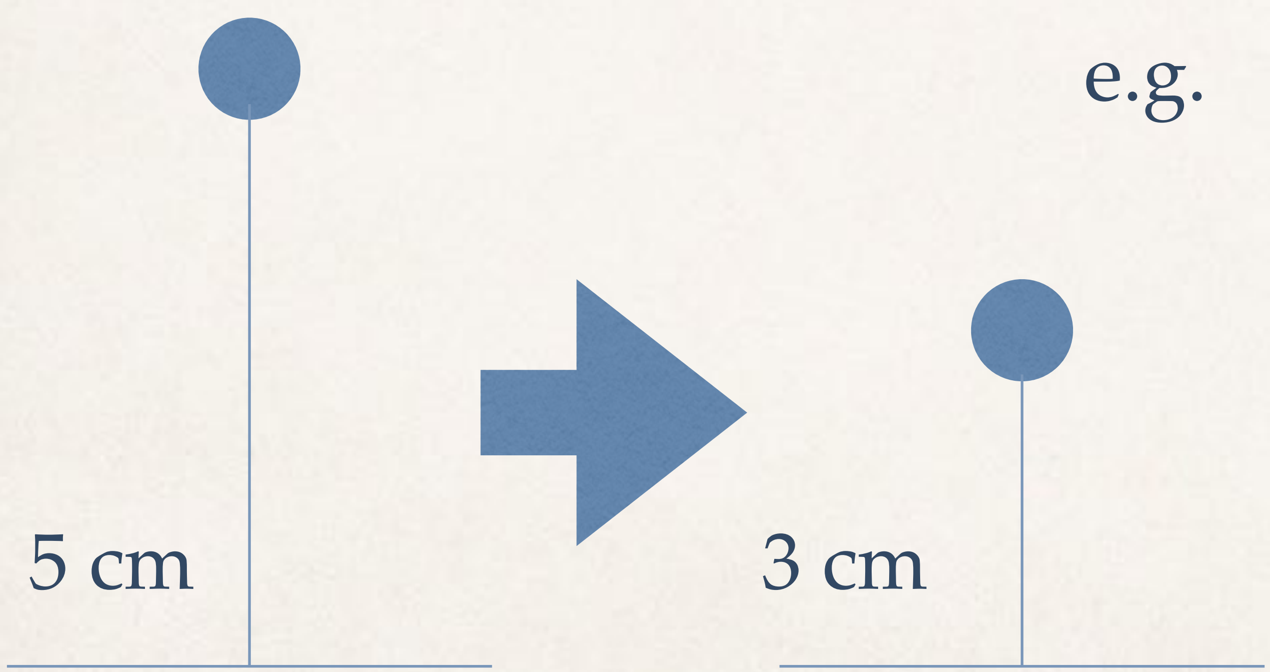
Velocity (v) : the rate of change of position with time

$v = dy\ /dt$

d : **d**ifference oder **d**elta

t : **t**ime

e.g.



14:02:05 14:02:06

dy =2 (cm)

dt = 1 (Sek.)

v = 2 cm/s

4.1 A Simple Mechanical System

acceleration (a) : the rate of change of velocity with time

$v = dy / dt$

$a = dv / dt$

d : **d**ifference oder **d**elta

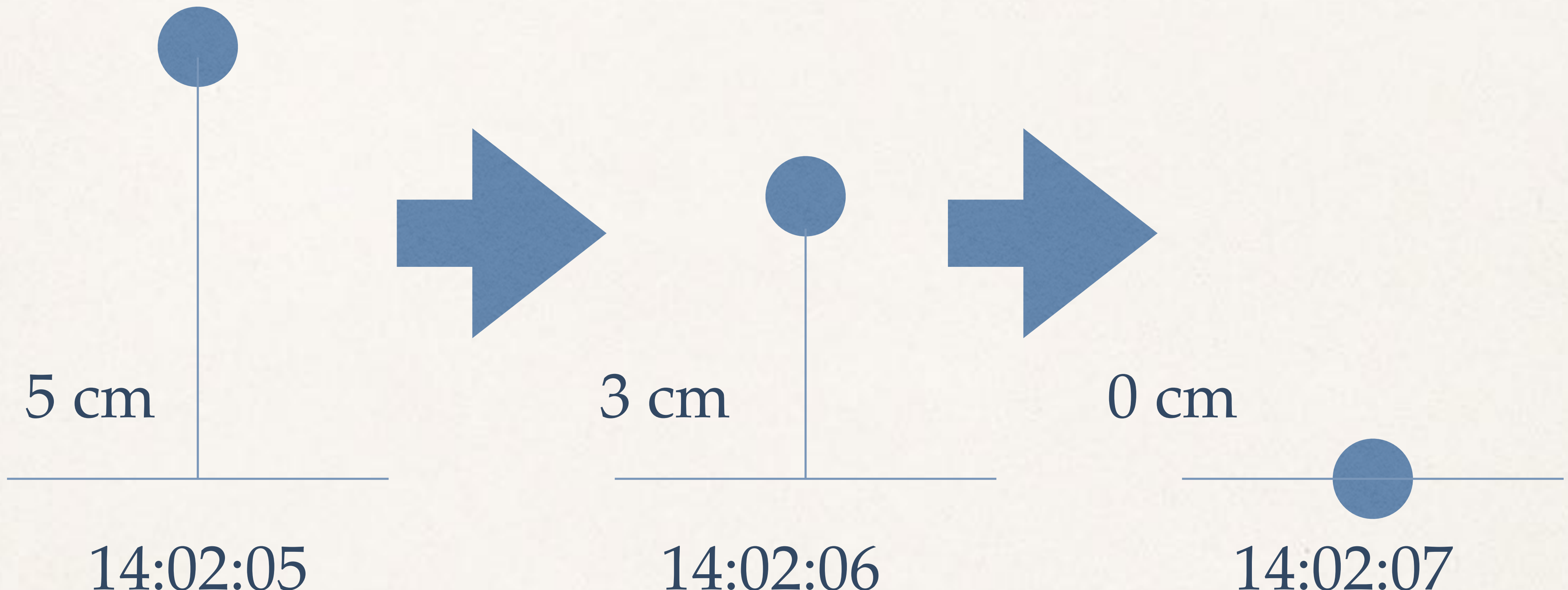
t : **t**ime

v : **v**elocity

$$a = dv / dt = \underline{d^2 y / dt^2}$$

zweite Ableitung

4.1 A Simple Mechanical System



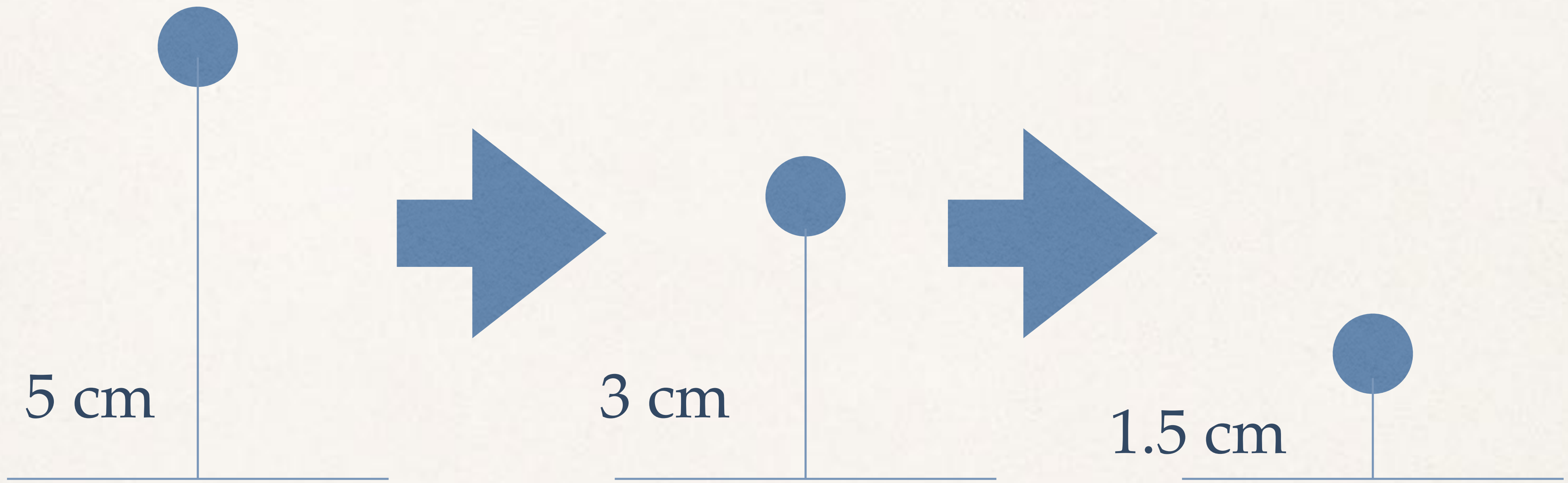
$dy = 2$ $dy = 3$

$v = 2\ cm\ /\ sek$ $v = 3\ cm\ /\ sek$

$dv = 1\ cm\ /\ sek$

$a = 1/1 = 1$

4.1 A Simple Mechanical System



14:02:05 14:02:06 14:02:07

dy = 2

dy = 1,5

v = 2 cm / sek

v = 1,5 cm / sek

dv = -0,5 cm / sek

a = -0,5 / 1 = -0,5

4.1 A Simple Mechanical System

1) $-ky - mg - r\mathbf{v} = m\mathbf{a}$

2) $v = dy / dt$

3) $a = d(dy / dt) / dt = d^2y / dt^2$

$-ky - r\mathbf{dy/dt} = m\mathbf{d^2y / dt^2}$

oder

$d^2y / dt^2 + (r/m)\, dy/dt + (k/m)\, y = 0$

4.2 Solution of the Mass/Spring/ Damper System

T … Abtastintervall

t = T * n

4.2 Solution of the Mass/Spring/Damper System

$$\overset{dy}{}\qquad\qquad\overset{dt}{}$$

1) $v = dy\ /dt = \mathbf{(y(n) - y(n\text{-}1))\ /\ T}$

(jetzige Position-letzte Position) / Abtastinterval

2) $a = dv/dt\ = d^2y\ /\ dt^2$

$$\overbrace{\mathbf{((\underbrace{y(n) - y(n\text{-}1))\ /\ T}_{v1} - \underbrace{(y(n\text{-}1) - y(n\text{-}2))\ /\ T}_{v2})}}^{dy}\ \mathbf{/\ \overset{dt}{T}}$$

$$= \mathbf{(y(n) - 2y(n\text{-}1) + y(n\text{-}2))\ /\ T^2}$$

4.2 Solution of the Mass/Spring/Damper System

$$-ky - mg - r\mathbf{v} = m\mathbf{a}$$

3) $$\underline{d^2y / dt^2} + (r/m)\,\underline{dy/dt} + (k/m)\;y = 0$$

2) 1)

$$(y(n) - 2y(n-1) + y(n-2)) / T^2 + r/m(y(n) - y(n-1)) / T + k/m\,y(n) = 0$$

or $$y(n) = y(n-1)(2m + Tr)/(m + Tr + T^2k) - y(n-2)m/(m + Tr + T^2k). \quad (4.5)$$

4.2 Solution of the Mass/Spring/ Damper System

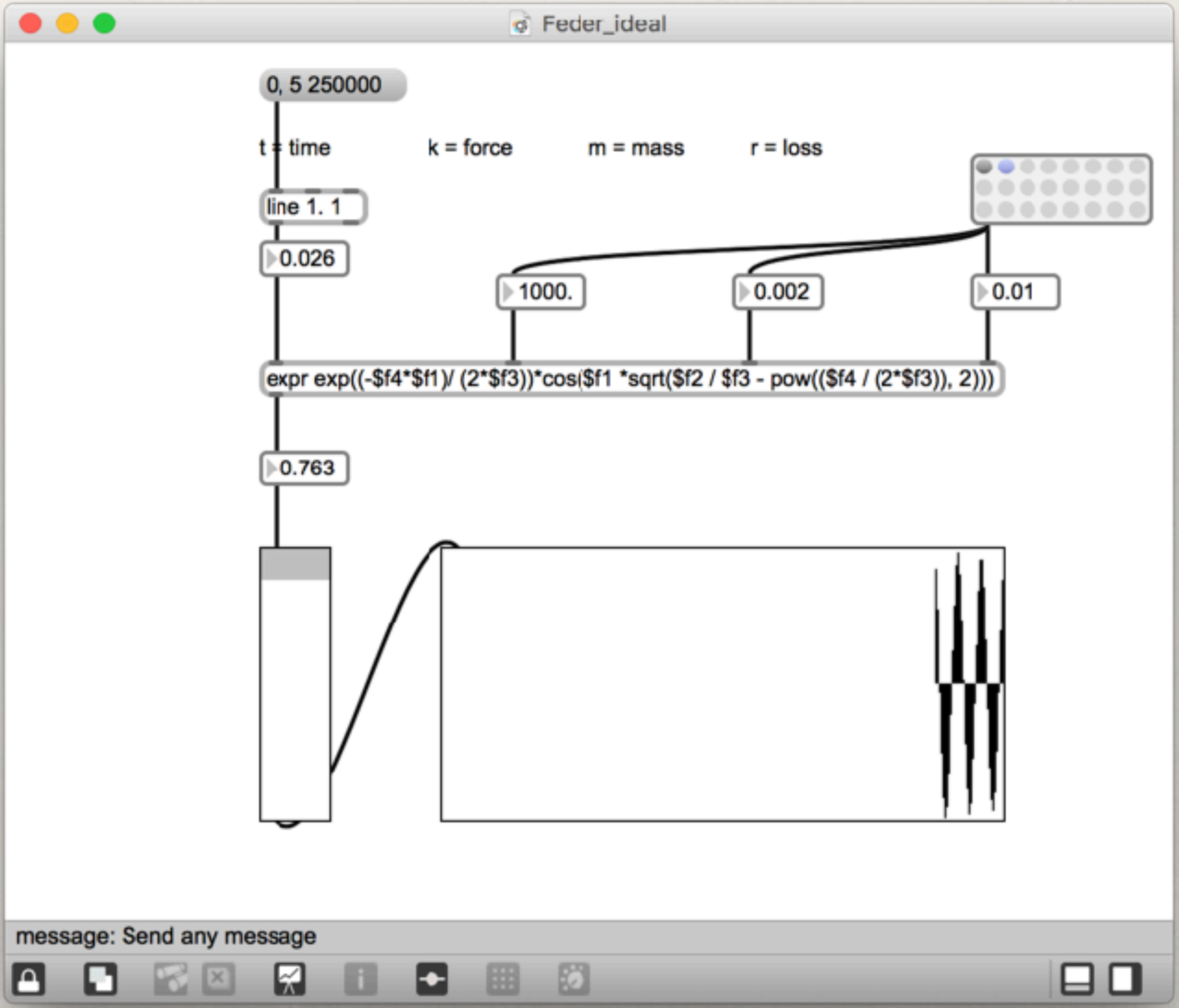
Mathematische Notation

$$y(t) = y_0 e^{(-rt/2m)} cos\left(t\sqrt{(k/m - (r/2m)^2)}\right). \qquad (4.3)$$

k = Kraft
r = Verlust
m = Masse
t = Zeit

4.2 Solution of the Mass/Spring/ Damper System

Experiment im Max



Klangbeispiel

4.3 Boundary Conditions

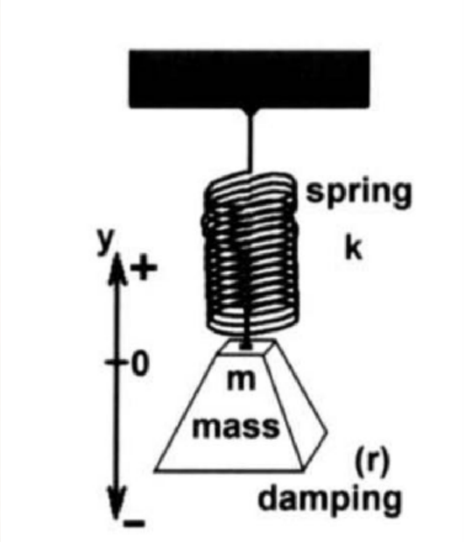
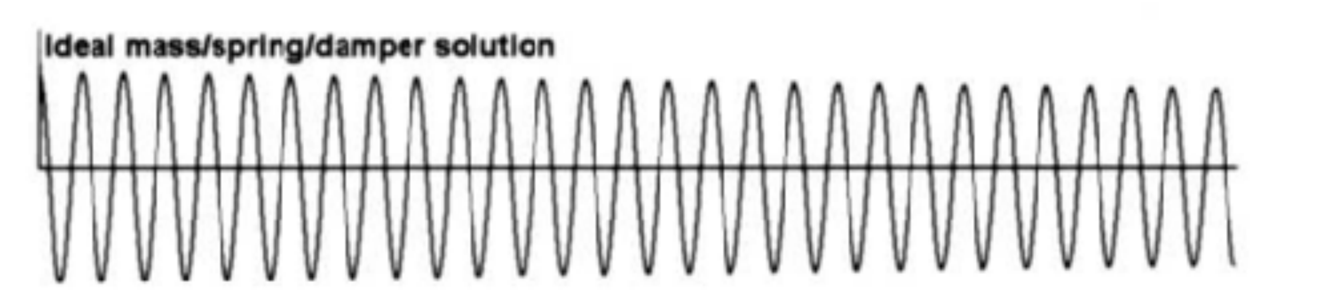
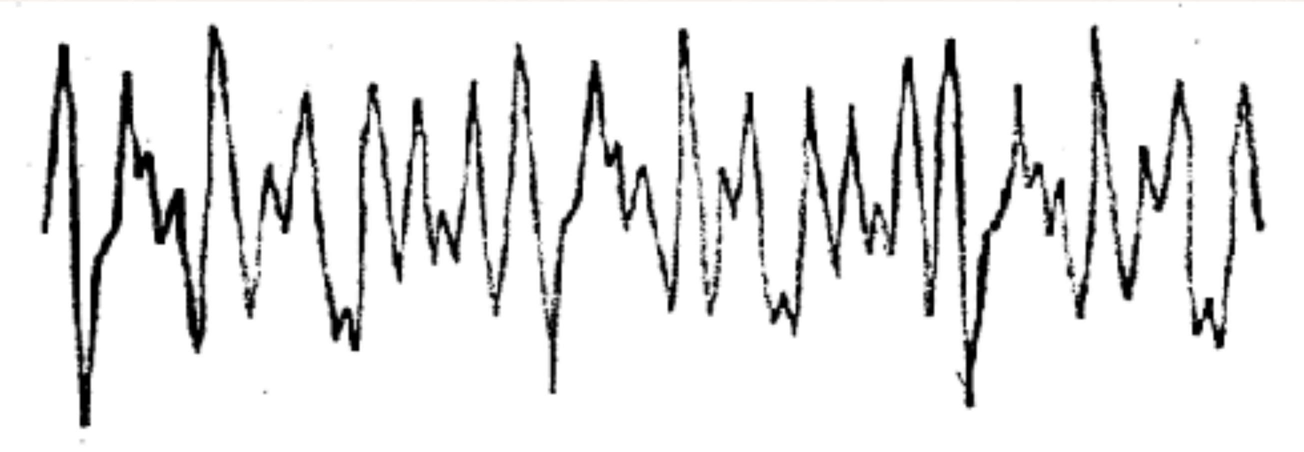


Figure 4.1. Mass/spring system.

ein einfaches System



ein System in der realen Welt



4.3 Boundary Conditions

- Ist das möglich mathematische Formeln für alle Systeme zu schreiben / definieren?

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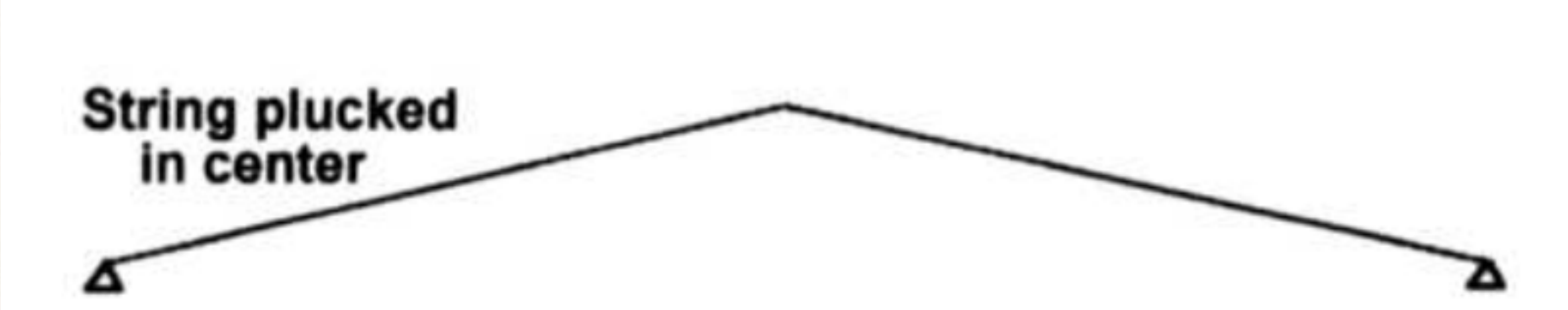
*Mathematical expressions of the physical forces can be written for nearly any system but solving such equations is **often** difficult or impossible*

Ausnahme?

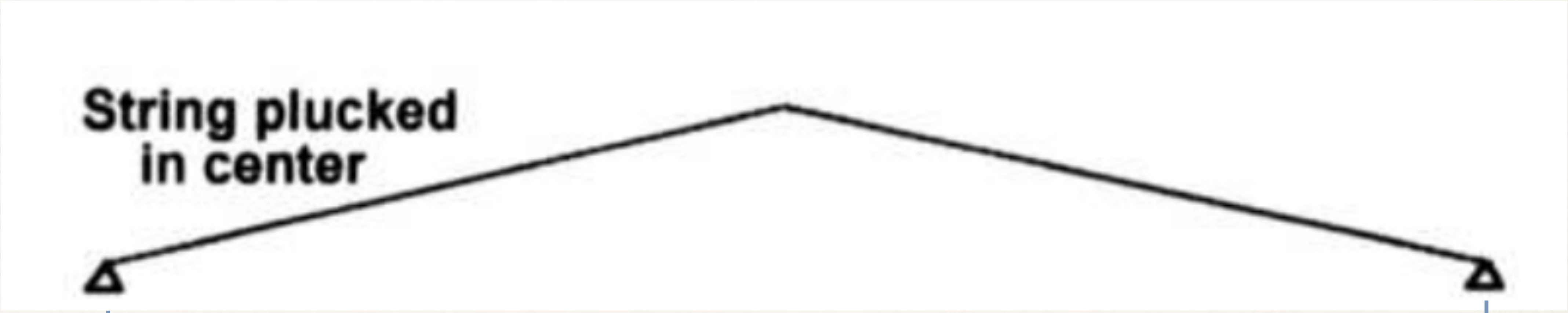
4.3 Boundary Conditions

Ausnahme?

A String under a tension



4.3 Boundary Conditions



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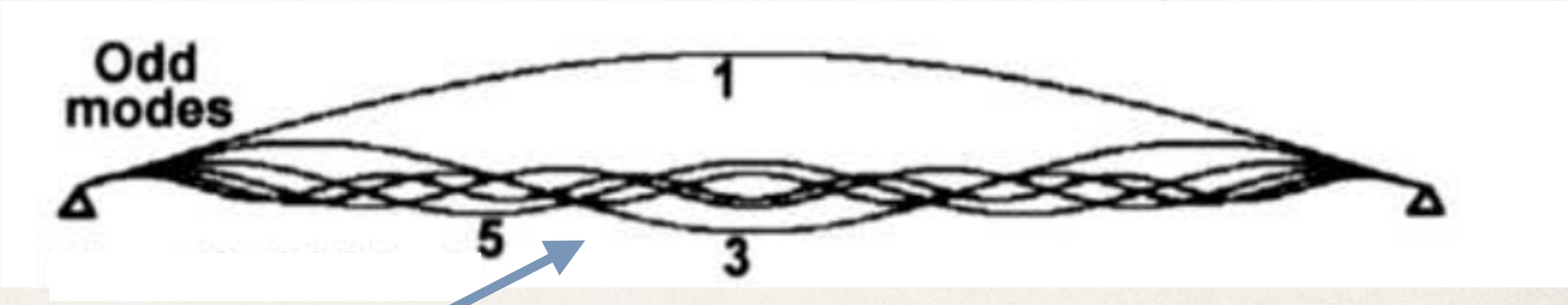

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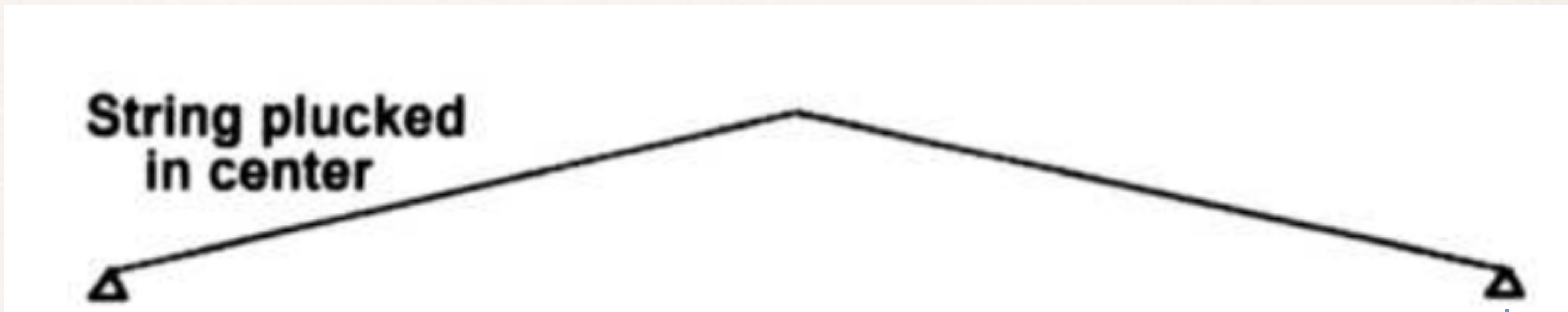
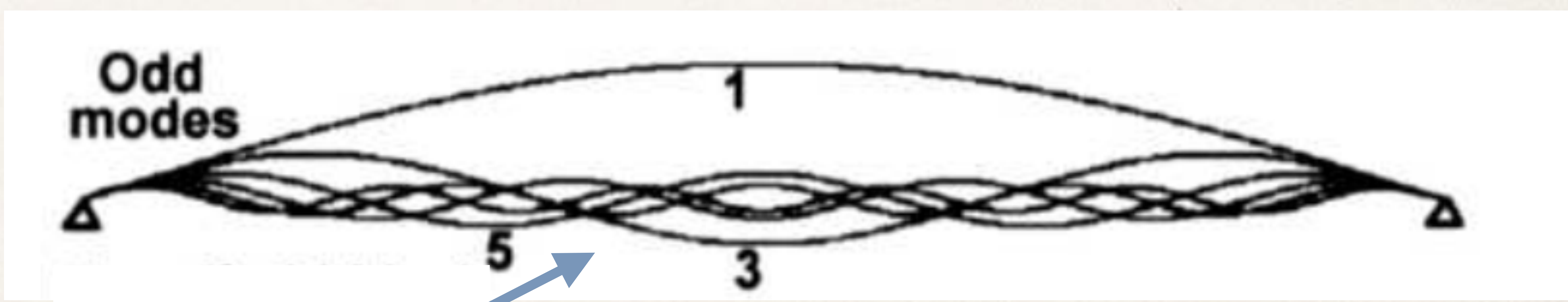
4.3 Boundary Conditions



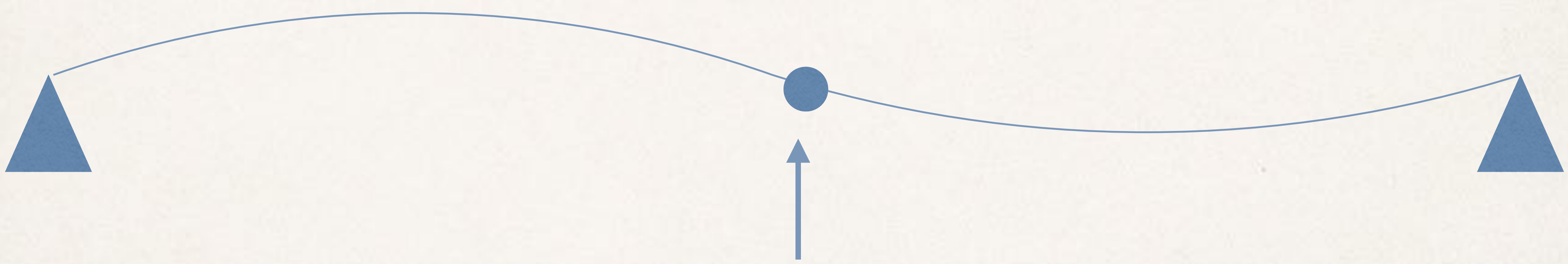
(Boundary Conditions)



(Boundary Solution)

4.3 Boundary Conditions

2nd mode

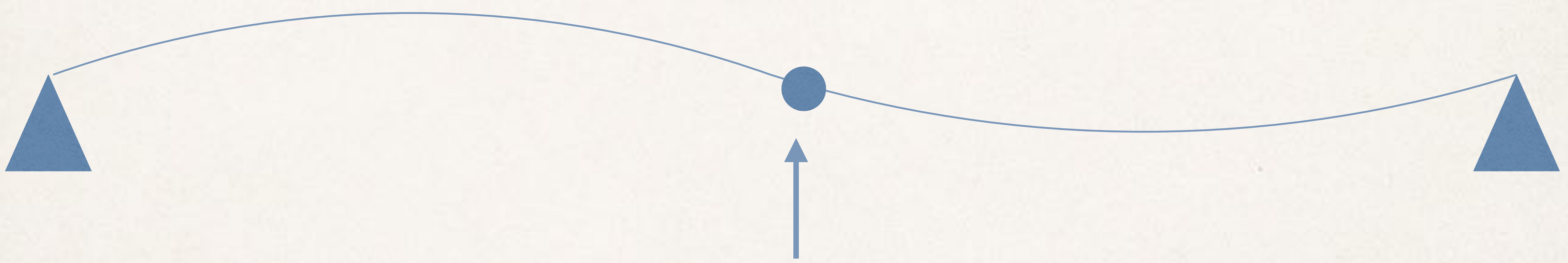


( )

zero crossing point

4.3 Boundary Conditions

2nd mode



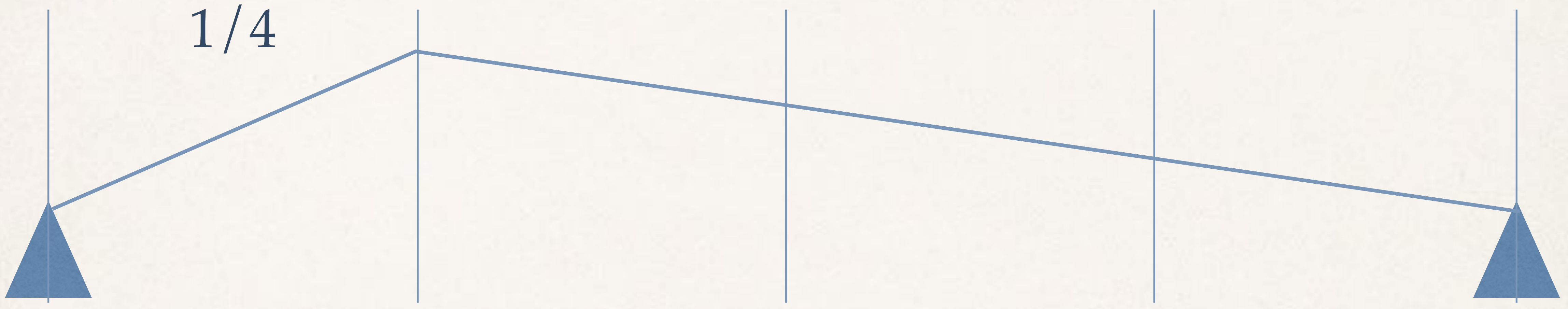
(node)

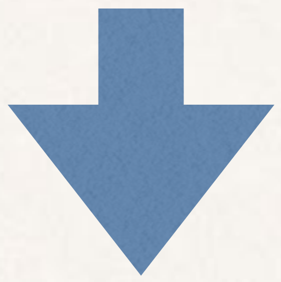
zero crossing point

4.3 Boundary Conditions

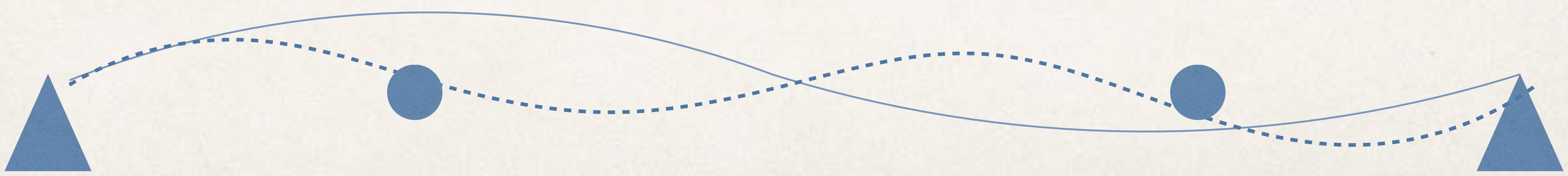
if we plucked the string at a position one fourth of the way along the string length, we would excite the second mode quite strongly, but the fourth mode would not be excited at all.

4.3 Boundary Conditions





2nd mode

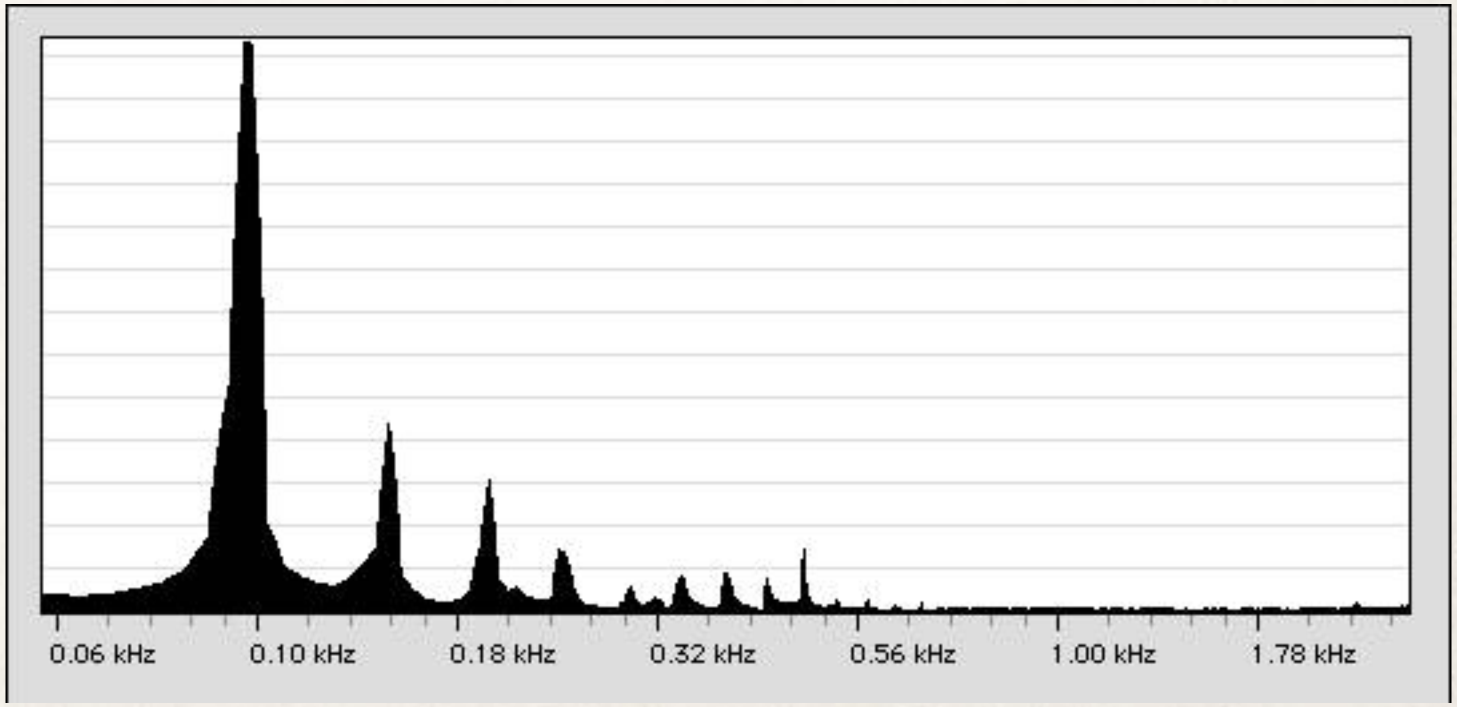


4th mode (nicht erzeugt)

4.4 Sinusoidal Additive Synthesis

many sound producing objects and systems exhibit strong sinusoidal modes.

Gittare

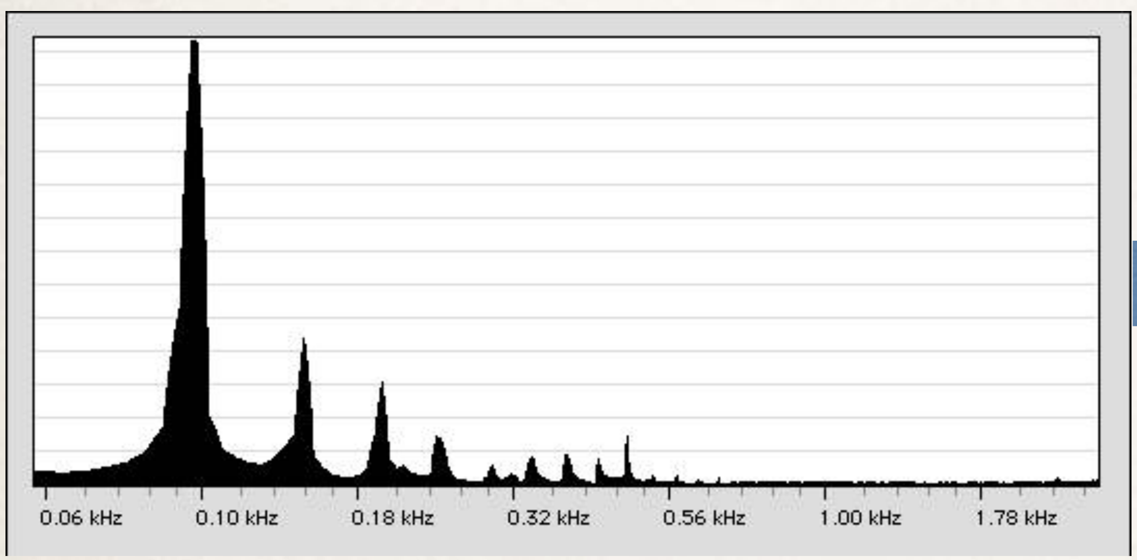


4.4 Sinusoidal Additive Synthesis

The recognition of the fundamental nature of the sinusoid gives rise to ***a powerful model*** *sound synthesis based on simply summing up lots of sinusoidal modes.*

4.4 Sinusoidal Additive Synthesis

Modeling



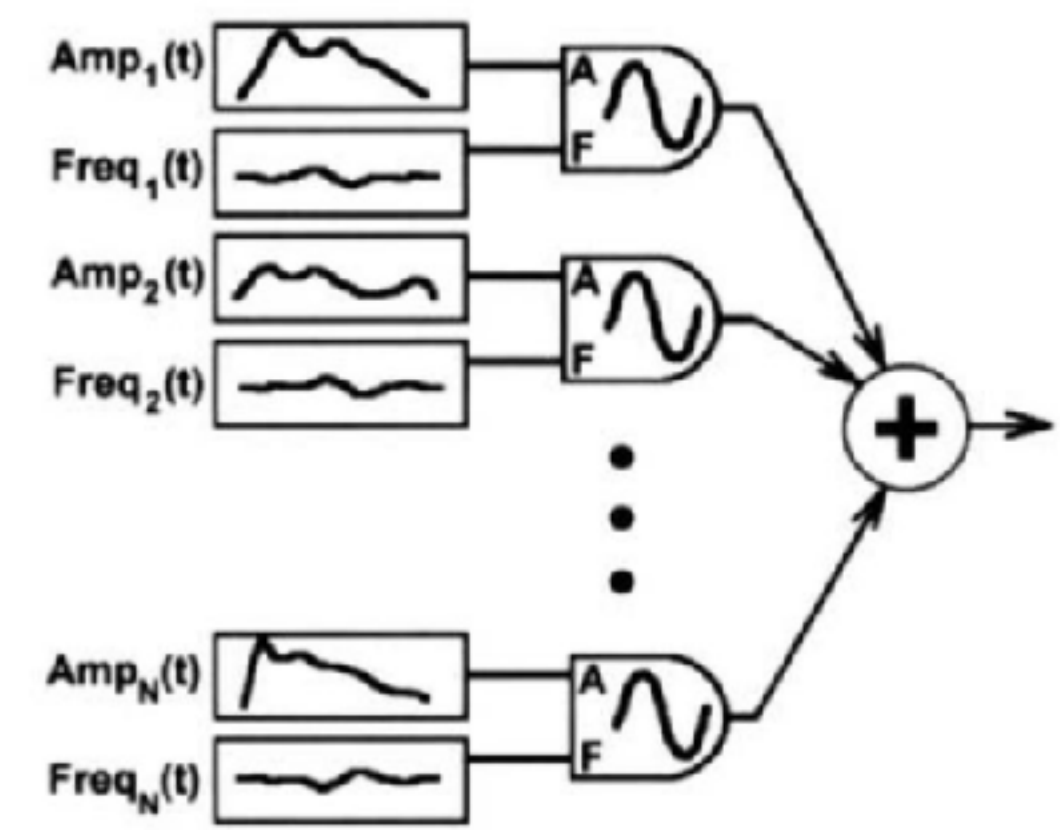
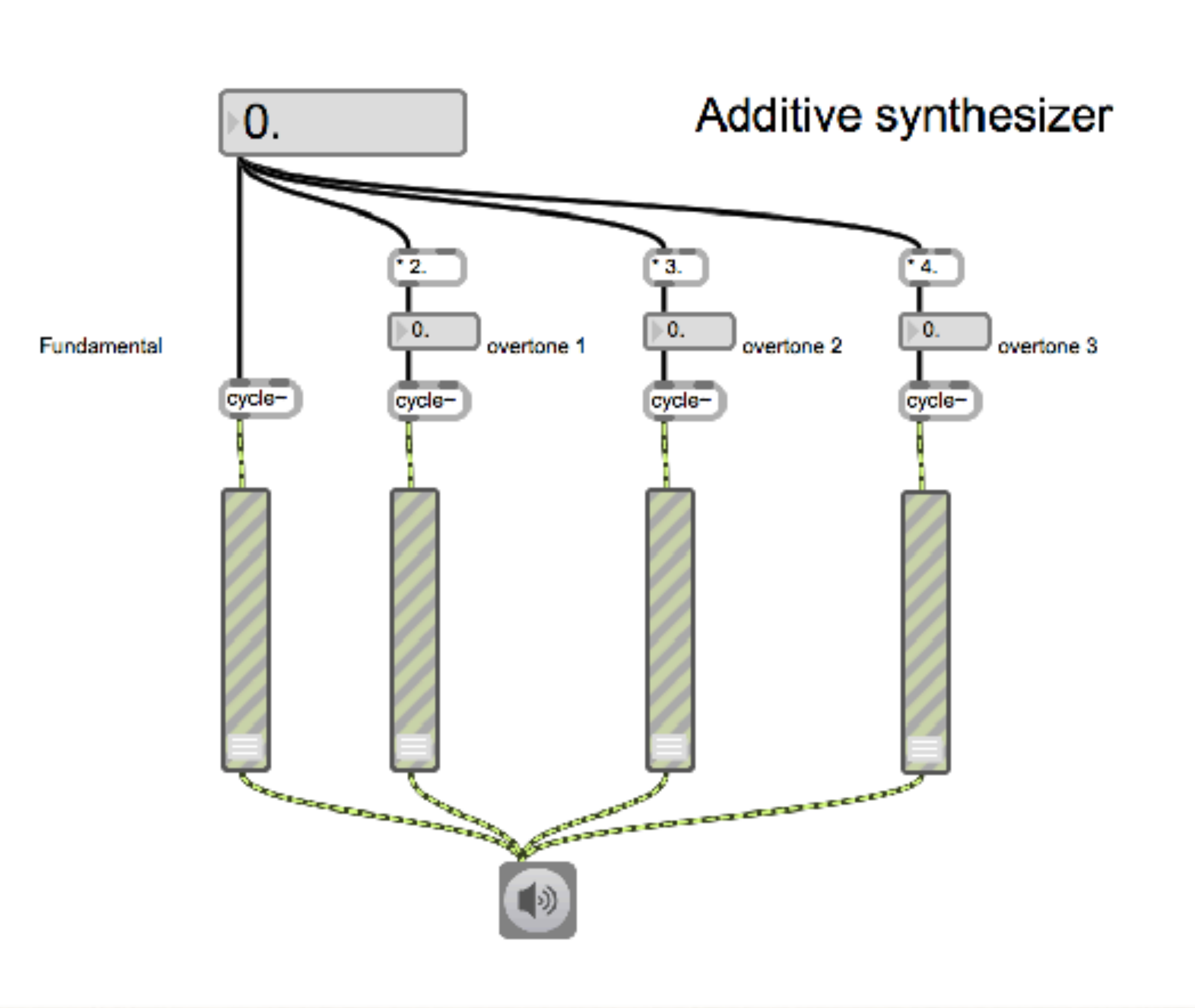


Figure 4.4. Sinusoidal additive synthesis algorithm.

4.4 Sinusoidal Additive Synthesis

Experiment im Max



4.5 Filter-Based Modal Synthesis

- Warum ist filter nützlich?
- Was ist die Beziehung zwischen Filter und Feder?

4.5 Filter-Based Modal Synthesis

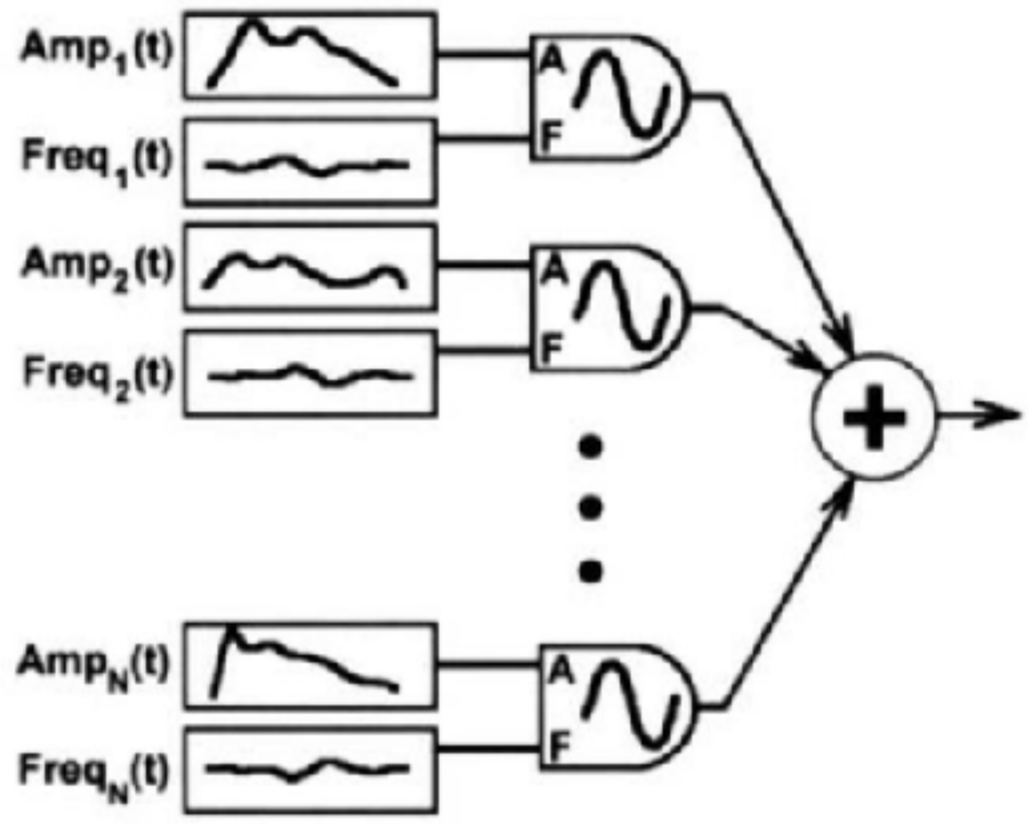


Figure 4.4. Sinusoidal additive synthesis algorithm.

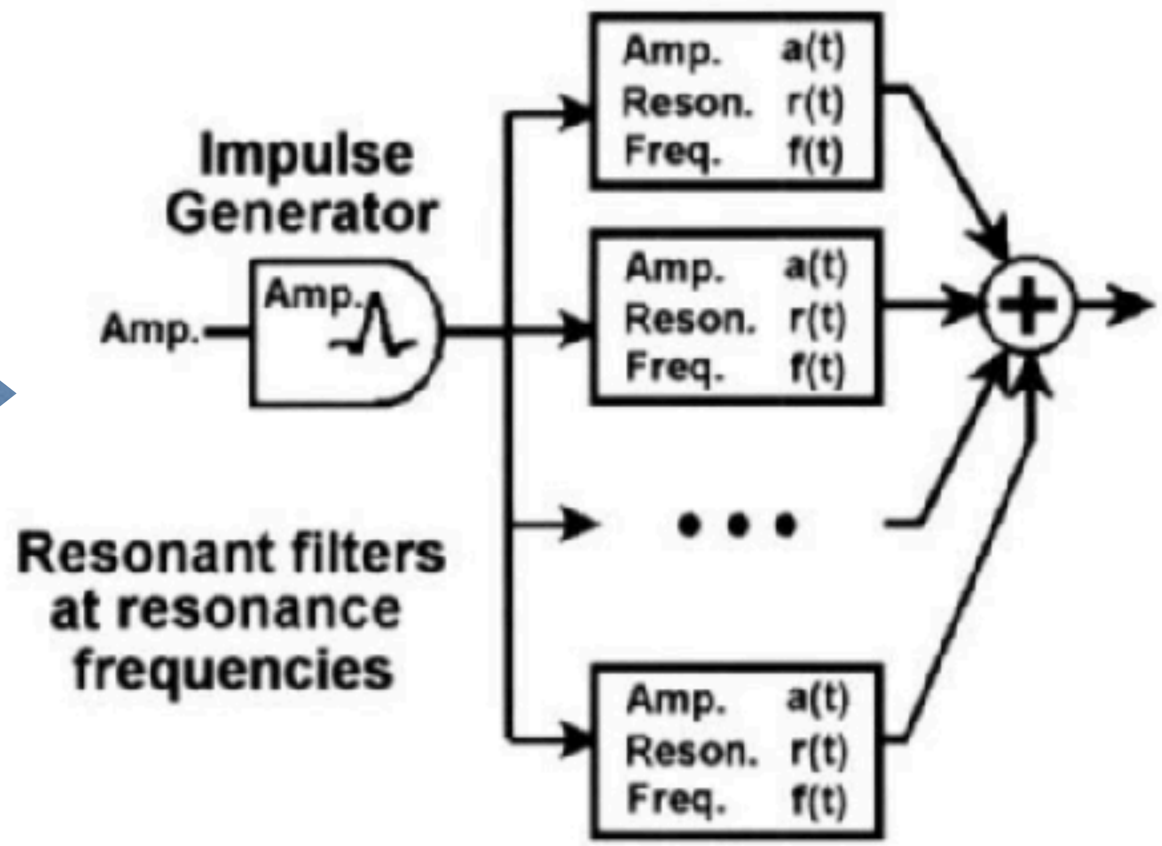
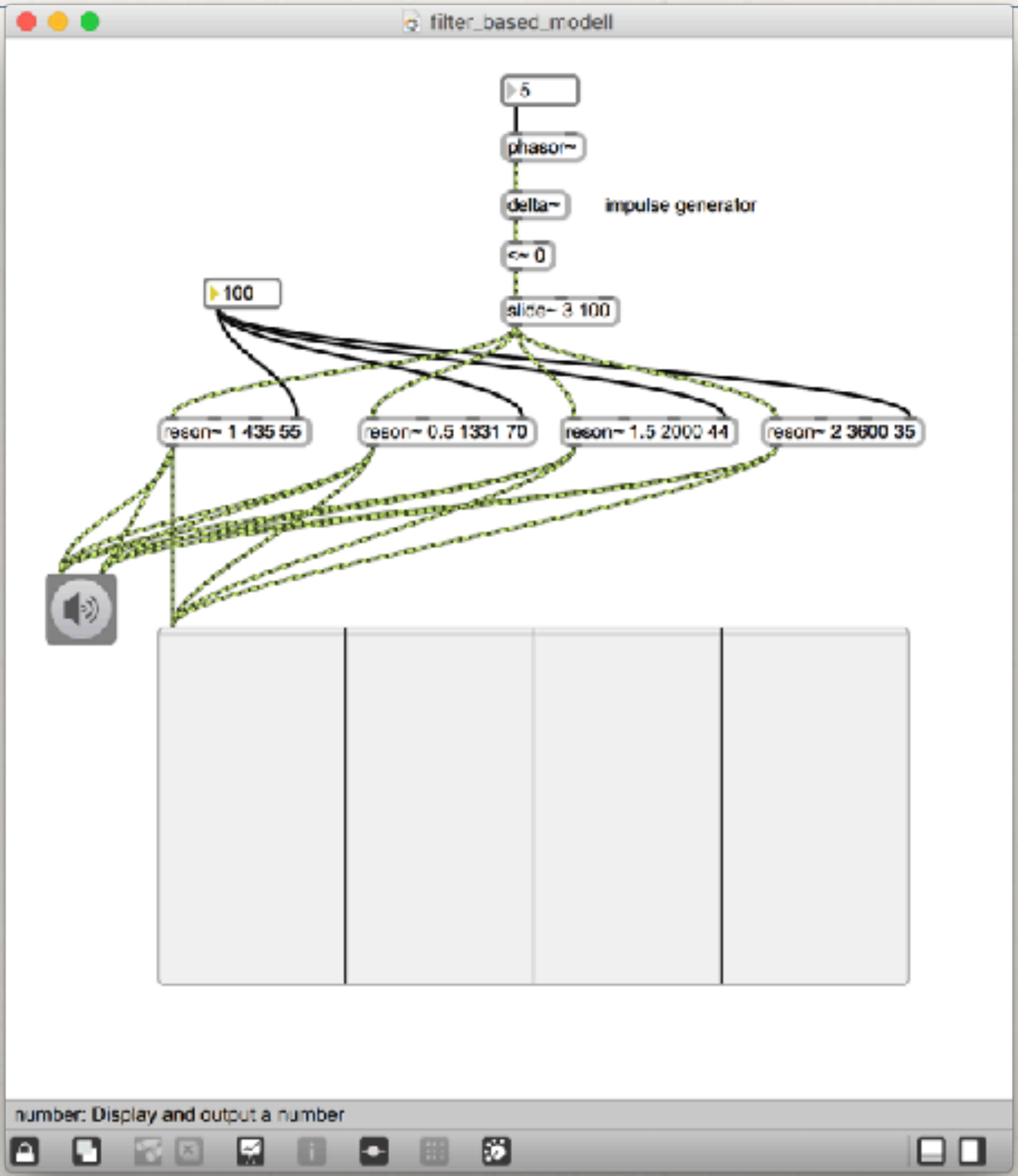


Figure 4.5. Simple modal synthesis algorithm.

4.5 Filter-Based Modal Synthesis

Experiment mit Max



4.5 Filter-Based Modal Synthesis

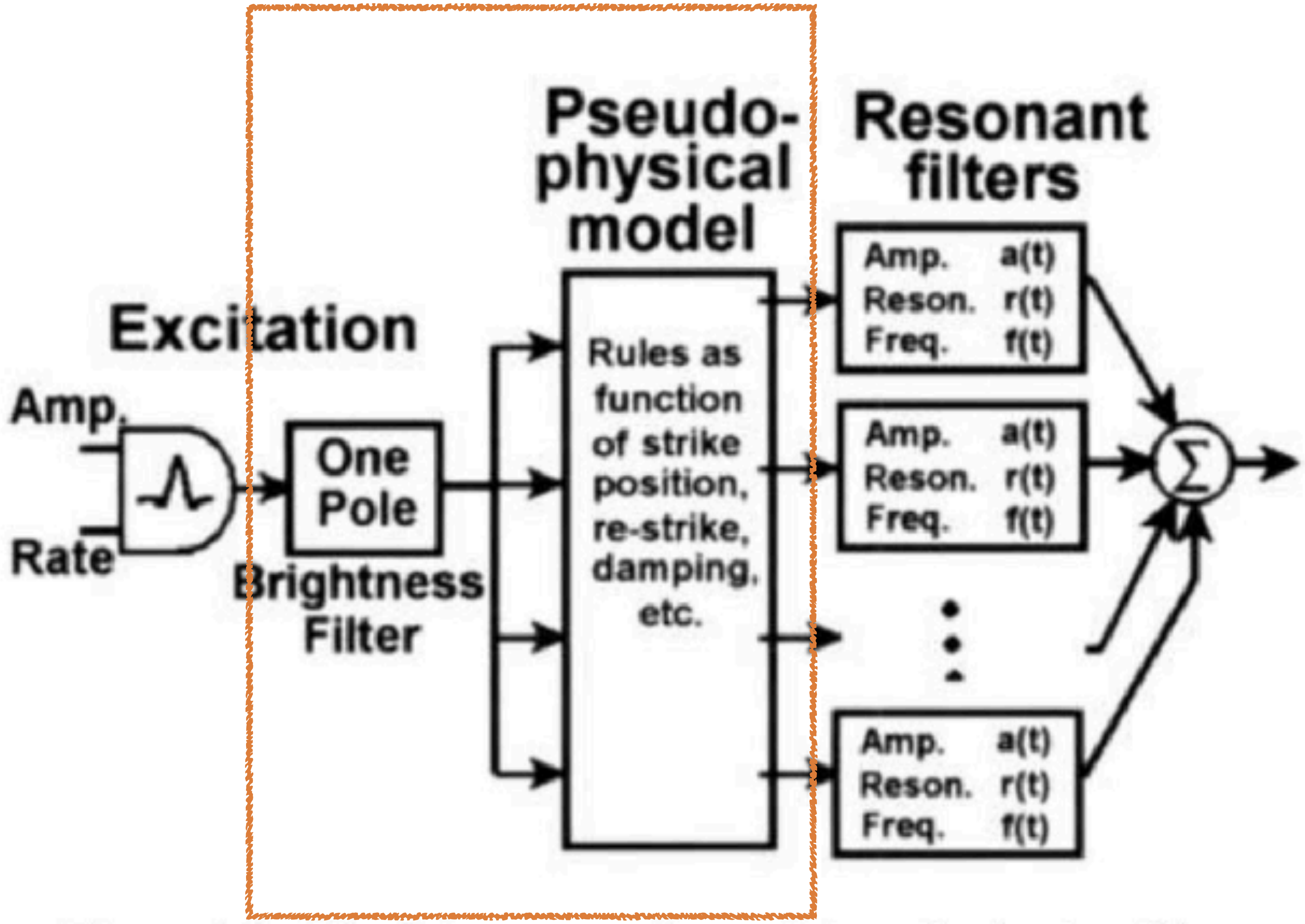


Figure 4.6. Flexible parametric modal synthesis algorithm.

4.6 Residual Extraction

- Residual?

4.6 Residual Extraction

- Residual?

  Part of the sound left over after the **modes** are removed

4.6 Residual Extraction

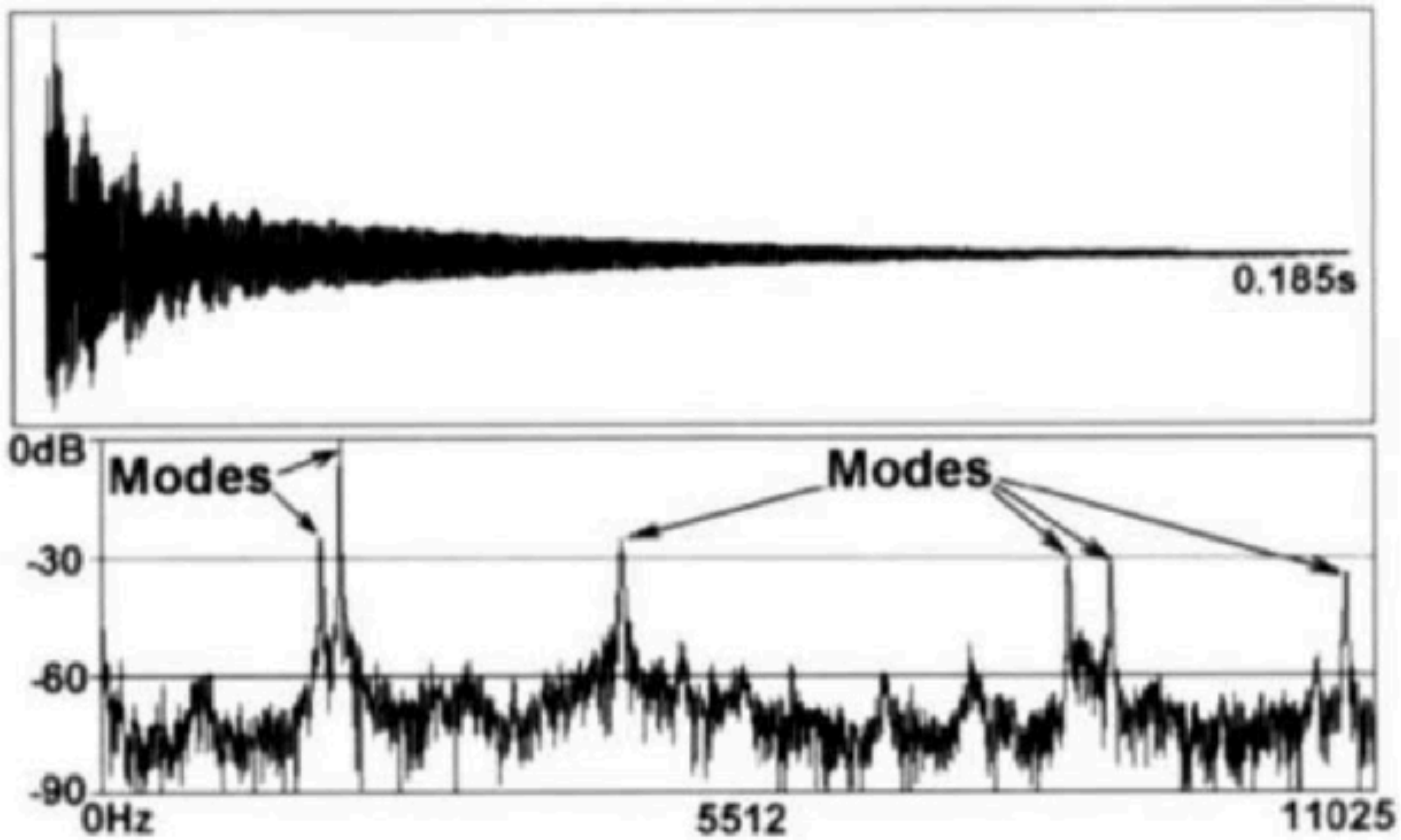


Figure 4.7. Waveform and spectrum of coffee mug struck with pencil. Note that there appear to be about six significant modes.

4.6 Residual Extraction

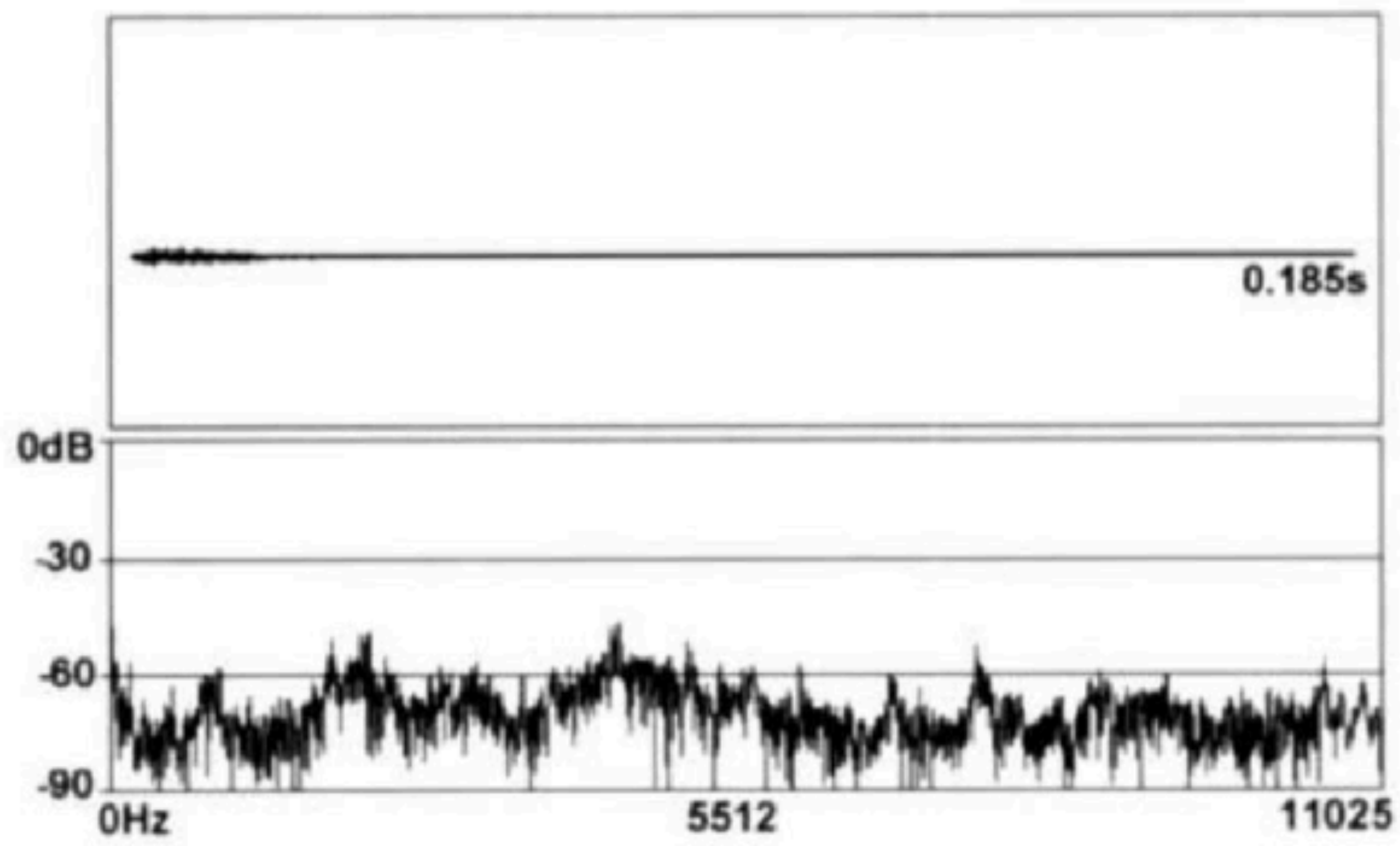


Figure 4.8. Waveform and spectrum of coffee mug residual after modes are removed (right).

Spectral Modeling Synthese

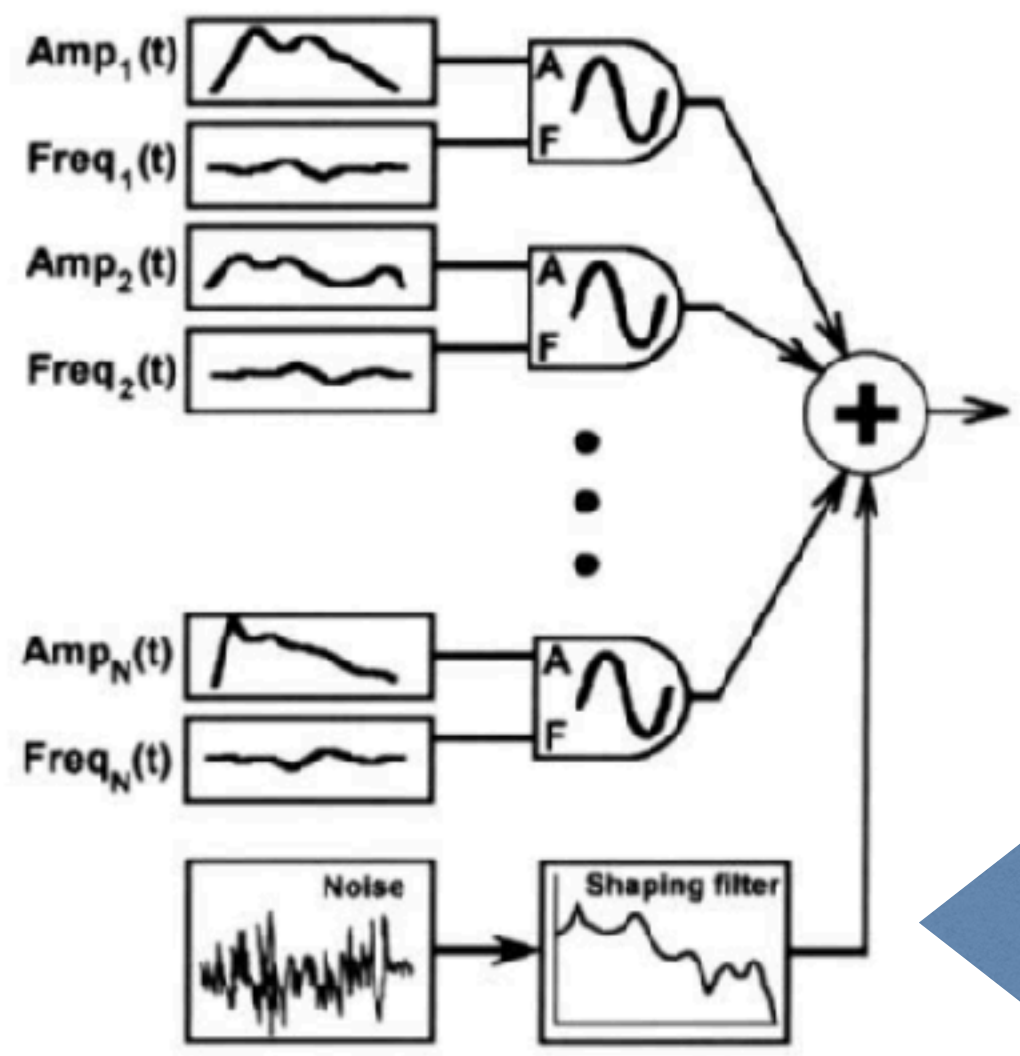
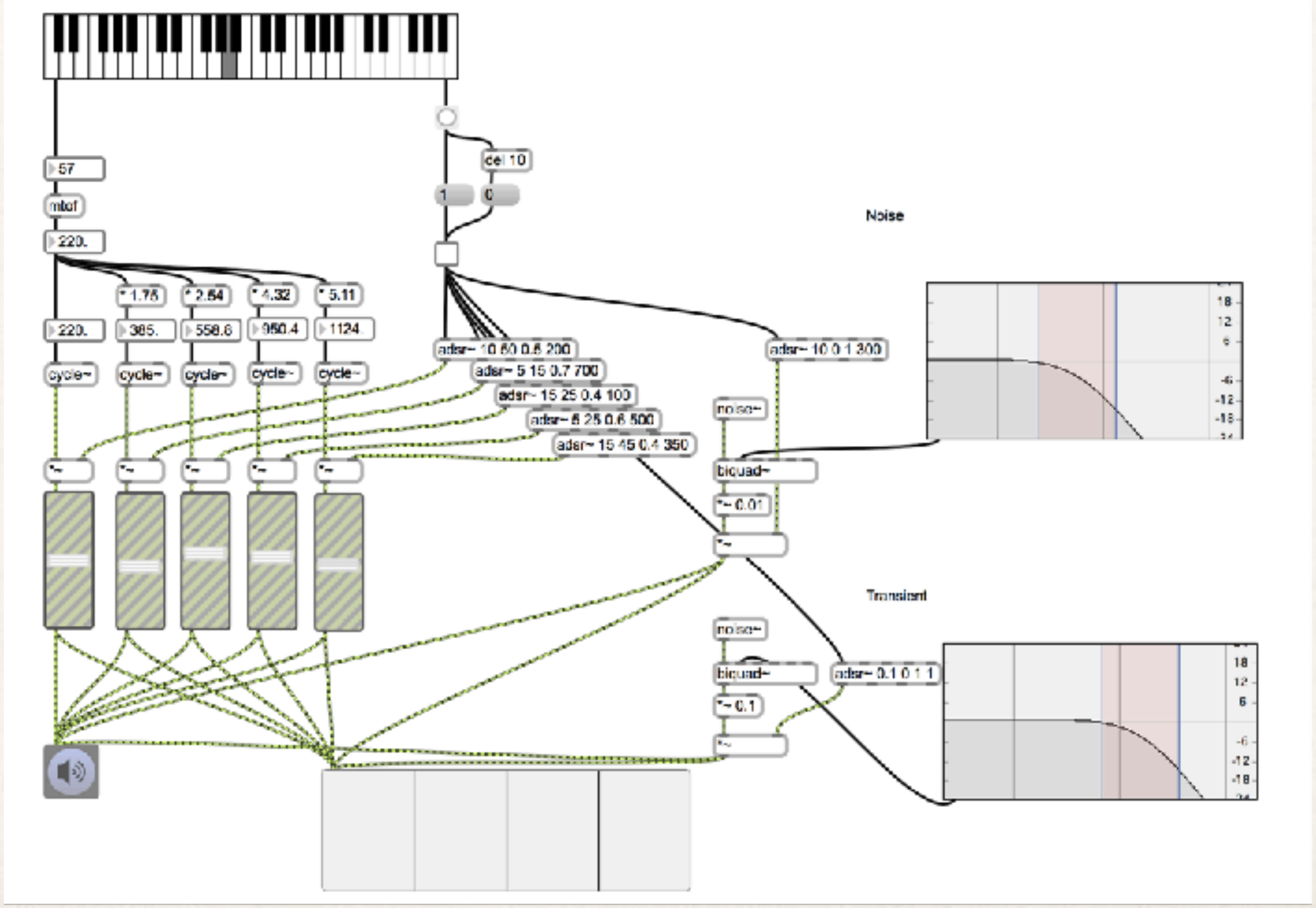


Figure 6.13. Sinusoidal additive model with filtered noise added for spectral modeling synthesis.

Residual

Experiment mit Max



Eigenschaft : Modal Synthese

Modal Synthese funktioniert sehr gut die Klänge der

- (　　　?　　　)
- (　　　?　　　)

zu simulieren.

Eigenschaft : Modal Synthese

Modal Synthese funktioniert sehr gut die Klänge der

- Zopfinstrumente
- Schlagzeuginstrumente

zu simulieren.

Modal Synthese / Beispiel

Wood

Metal

4.7 Conclusion