

# Modelica and Virtual Education

## Modelica Conference 2019, Regensburg, Germany

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2019-03-05

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- 1 Online Quiz
- 2 Modelica Book
- 3 Introduction
- 4 Letto and Modelica
- 5 Virtual Modelica Lab
- 6 Conclusions

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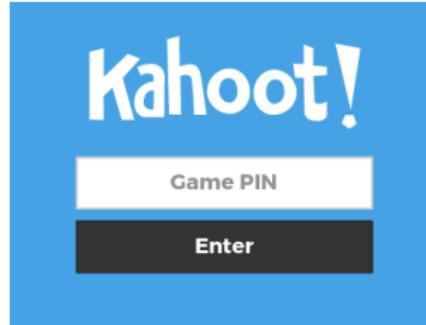
4 Letto and Modelica

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# Online Quiz

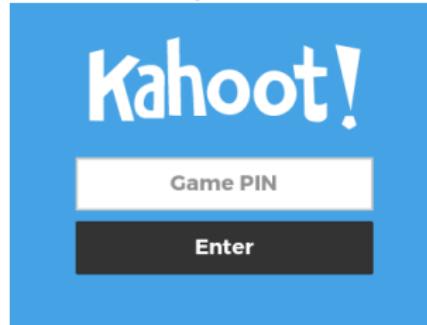
- Go to <https://kahoot.it/>



- Create your own quiz at <https://kahoot.com/>

# Online Quiz

- Go to <https://kahoot.it/>



- Create your own quiz at <https://kahoot.com/>

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# Modelica Book

Go to <https://kahoot.it/>



- Theory and practice
- Modelica for electrical engineers
- Polyphase electrical machines
- Including GitHub tutorial
- Link to [Hanser](#) (publisher)
- Link to [video tutorial](#)
- Open Source
  - Software [OpenModelica](#)
  - Examples and models

Look into the book  
at the booth of LTX

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# Introduction

## Education of engineers

- Theory classes
- Exercises in class or homework
- Laboratory
- Simulation (e.g., with Modelica)

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# Lotto

## Lotto means

- **L**earning
- **E**valuating
- **T**eaching
- **T**esting
- **O**nline

## Lotto

- Webpage and Wiki at <https://www.lotto.at/>
- Commercial software
- Running on Linux server

# Letto Key Performance Indicators

## Customized for technical studies

- Text, data and calculations in one database
- Full support of **Maxima**  
(open source computer algebra system)
- Supports quantities = numbers and units
- Symbolic calculations
- Real and complex number calculations
- Management of students classes and subjects
- Support of syllabus competences
- Online exercises, exams and grading
  - ▶ Student may access actual contributions and grades
  - ▶ Compliant with General Data Protection Regulation

# Letto Key Performance Indicators

## Individual Data Examples

- Specified data range of parameters
- Real and complex number calculations
- Powerful plugins
  - ▶ DC circuit generator
  - ▶ AC circuit generator
  - ▶ Analog meter
  - ▶ Digital graphs (RS 232, UART, etc.)
  - ▶ Graph (Maxima)
  - ▶ Freehand sketch
  - ▶ Source code (Java, Java script, C)

# Letto Key Performance Indicators

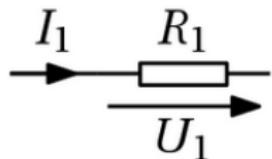
## Types of examples

- Multiple choice questions
- Multiple answer calculations
  - ▶ Calculation accuracy
  - ▶ Multiple »correct« answers
  - ▶ Handle subsequent errors
- Mapping questions and answers
- Gap text exercises
- Free text fields

# Letto Multiple Choice Example

## Ohm's law

A voltage of  $U_1 = 400 \text{ V}$  is applied to a resistor of  $R_1 = 0.4 \text{ k}\Omega$ .



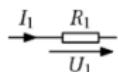
Determine the current through the resistor:

- $I_1 = 1 \text{ A}$
- $I_1 = 1000 \text{ mA}$
- $I_1 = 10 \text{ A}$
- $I_1 = 100 \text{ mA}$
- $I_1 = 100 \text{ A}$
- $I_1 = 10 \text{ mA}$

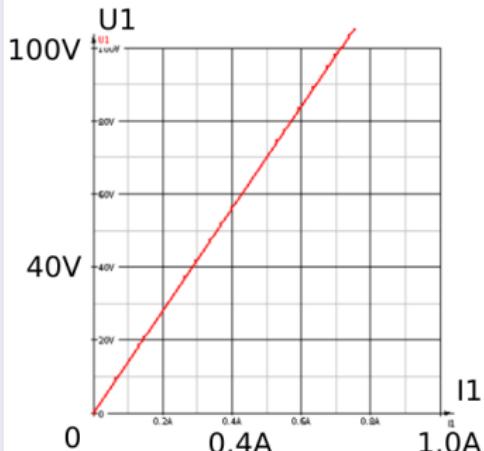
**Prüfen**

# Letto Multiple Answer Example

## Ohm's law



(a) Determine the resistance  $R_1$  from the following load line:

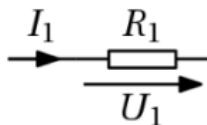


(b) Determine the current  $I_1$  when the resistor is operated at  $U_1 = 60 \text{ V}$ :

(c) Determine the power dissipated in the resistor when operated at  $U_1 = 60 \text{ V}$ :

# Letto Meter Reading

## Ohm's law



You are investigating a resistor in the lab



(a) Read the voltmeter:  $U_1 =$

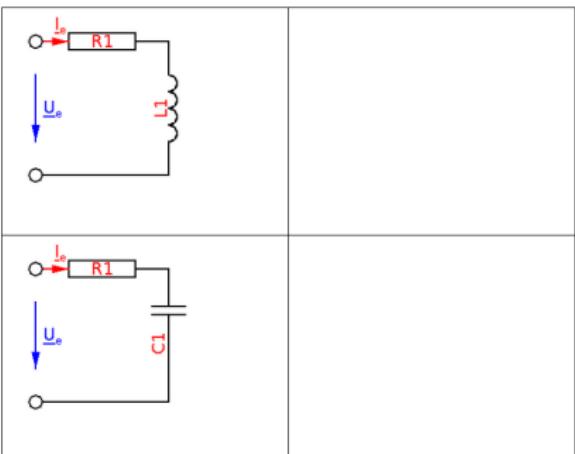


# Letto Matching Question and Answer

## Complex AC series circuit

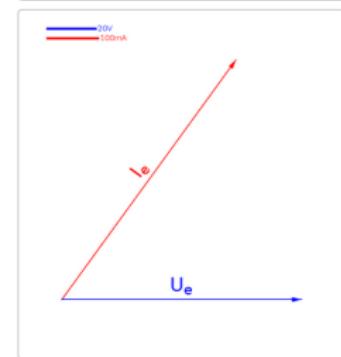
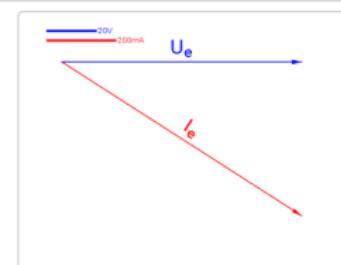
Match the circuits and phasor diagrams

Ziehen Sie bitte die Antworten in die freien Felder



Zurücksetzen

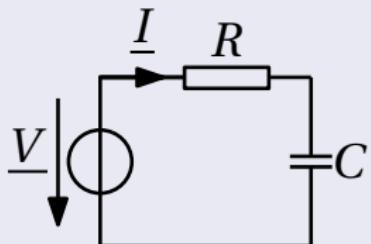
Antworten



# Letto + Modelica Example

## Example

- Investigation of R-C series circuit
- Individual exercise data
- Complex supply voltage  
 $V = V\angle\phi iV$
- Resistance R
- Capacitance C
- Frequency f



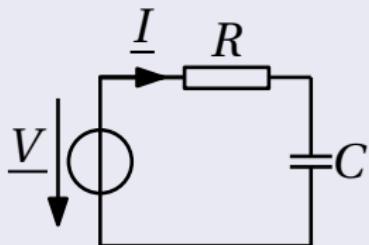
## Determine

- Phase angle of impedance phi
- Active power P
- Reactive power Q
- Apparent power S

# Letto + Modelica Example

## Example

- Investigation of R-C series circuit
- Individual exercise data
- Complex supply voltage  
 $V = V\angle\phi iV$
- Resistance R
- Capacitance C
- Frequency f



## Determine

- Phase angle of impedance phi
- Active power P
- Reactive power Q
- Apparent power S

# Letto + Modelica Example

## The starting point

### Lecturer

- Specification of task by PDF document
- Individual exercise data stored in CSV file
- Provided through Moodle

#	Name	V	phiV	f	R	C	phi	P	Q	S
-	-	V	°	Hz	Ohm	uF	°	W	var	VA
1	Name 1	240	30	50	100	118.8				
2	Name 2	240	45	60	150	30.63				
3	Name 3	220	60	75	100	21.22				
4	Name 4	220	90	80	80	14.36				
5	Name 5	200	120	100	60	7.11				
6	Name 6	200	150	120	50	15.31				
7	Name 7	180	120	150	60	17.68				
8	Name 8	180	90	200	80	17.23				
9	Name 9	150	60	150	100	39.6				
10	Name 10	150	45	120	150	15.31				

# Letto + Modelica Example

## The starting point

### Students

- Download assignment
- Fill in individual results
- Upload CSV file on Moodle

#	Name	V	phiV	f	R	C	phi	P	Q	S
-	-	V	°	Hz	Ohm	uF	°	W	var	VA
1	Name 1	240	30	50	100	118.8				
2	Name 2	240	45	60	150	30.63				
3	Name 3	220	60	75	100	21.22	-45.0	484.0	-484.0	684.5
4	Name 4	220	90	80	80	14.36				
5	Name 5	200	120	100	60	7.11				
6	Name 6	200	150	120	50	15.31				
7	Name 7	180	120	150	60	17.68				
8	Name 8	180	90	200	80	17.23				
9	Name 9	150	60	150	100	39.6				
10	Name 10	150	45	120	150	15.31				

# Letto + Modelica Example

## The starting point

### Evaluation by lecturer

- Download all students results
- Compile all results into one student results file
- Create reference data (Modelica ▶ KeyWordIO)

#	Name	V	phiV	f	R	C	phi	P	Q	S
-	-	V	°	Hz	Ohm	uF	°	W	var	VA
1	Name 1	240	30	50	100	118.8	-75.0	576.0	-2149.8	2225.6
2	Name 2	240	45	60	150	30.63	-60.0	384.0	-665.1	768.0
3	Name 3	220	60	75	100	21.22	-45.0	484.0	-484.0	684.5
4	Name 4	220	90	80	80	14.36	-30.0	605.0	-349.4	698.6
5	Name 5	200	120	100	60	7.11	-15.0	666.7	-178.7	690.2
6	Name 6	200	150	120	50	15.31	-30.0	800.0	-461.7	923.7
7	Name 7	180	120	150	60	17.68	-45.0	540.0	-539.9	763.6
8	Name 8	180	90	200	80	17.23	-60.0	405.0	-701.5	810.0
9	Name 9	150	60	150	100	39.6	-75.0	225.0	-839.7	869.4
10	Name 10	150	45	120	150	15.31	-60.0	150.0	-259.7	299.9

# Lotto + Modelica Example

## The starting point

### Grading by lecturer

- Grading script (Python / Julia)
- Compare student results with reference data
- Provide grading scheme
  - ▶ Achievable points per question
  - ▶ Accuracy
- Degradation scheme
  - ▶ Wrong sign
  - ▶ Wrong magnitude of order
  - ▶ Accuracy exceeded
  - ▶ Subsequent error
- Grading

# Letto + Modelica Example

## The much better solution

- Import data into Letto
- Keep together
  - ▶ Exercise text
  - ▶ Data
  - ▶ Result tolerances
  - ▶ Grading scheme
- Post processing of data by Maxima
- Apply in one example
  - ▶ Multiple calculation
  - ▶ Multiple choice
  - ▶ Matching questions and answers

# Lotto + Modelica Example

## Lotto screenshot

Lotto screenshot showing a Modelica-based question editor.

**Kategorien:**

- Angewandte Mathematik (0|7)
- Antriebstechnik (0|298)
- Automatisierungstechnik (0|2)
- CPE (0|25)
- Elektronik (0|0)
- Energiesysteme (0|527)
- Grundlagen des Maschinenbaus
- Informatik (0|0)
- Labor (0|0)
- Mechatronik (0|0)

**Online-Tests:**

- 2018-19

**Vorschau:**

The circuit diagram shows a series connection of a voltage source  $V$ , a resistor  $R$ , and a capacitor  $C$ .

**Fragen Modelica Conference:**

**Fragenname:** Neue Mehrfach-Berechnungsfrage

**Frage:**

[IMGO]

An R-C series circuit has the following parameters:  $\$U = \{U\}$ ,  $\$R = \{R\}$ ,  $\$L = \{L\}$ ,  $\$f = \{f\}$

- Determine the phase angle  $\$varphi$  of the impedance [Q0]
- Determine the active power  $\$P$  [Q1]
- Determine the reactive power  $\$Q$  [Q2]
- Determine the magnitude of the apparent power  $\$S$  [Q3]

**Plugins:**

DS	Werte	EH
U	import:240,240,220 V	
phil	import:30,45,60,90 °	*
f	import:50,60,75,80 Hz	
R	import:100,150,100 Ohm	
C	import:118,8,30,63 uF	
iRe	import:2.07846,1.1 A	
iRim	import:1,2,1,13137 A	
iCre	import:-4.47865,-1.1 A	
iCim	import:7.75726,1.9 A	
iRe	import:-2.40019,-0. A	
iIm	import:8.95726,3.0 A	
iI	import:9.27326,3.2 A	

**Details zur Frage:**

Q.	Pkt.	Proz.	Maxima	EH	Mode	Tol	Lösung	Erg / Info
Q0	1.0	100	phi		CALCU	1.0%		
Q1	1.0	100	P		CALCU	1.0%		
Q2	1.0	100	Q	var	CALCU	1.0%		
Q3	1.0	100	S	VA	CALCU	1.0%		

**Maxima:**

```
S_complex:P+%i*Q
```

## Letto + Modelica Example

Categories ▶ teaching subjects ▶ semesters

The screenshot shows the Modelica Conference software interface. On the left, there's a sidebar with 'Kategorien' (Categories) containing links like 'Angewandte Mathematik (0|0)', 'Antriebstechnik (0|298)', etc., and 'Online-Tests:' with a link to '2018-19'. Below that is a 'Vorschau' (Preview) section showing a circuit diagram of a series RLC circuit with a voltage source  $V$ , resistor  $R$ , inductor  $I$ , and capacitor  $C$ .

The main workspace has tabs for 'Fragen', 'Modelica', and 'Conference'. The 'Fragen' tab is active, showing a question titled 'FrageDetails: Mehrfach-Berechnungsfrage'. The question text is:

An R-C series circuit has the following parameters:  $U = \{U\}$ ,  $R = \{R\}$ ,  $L = \{L\}$ ,  $f = \{f\}$

Sub-questions are listed:

- Determine the phase angle  $\varphi$  of the impedance [Q0]
- Determine the active power  $P$  [Q1]
- Determine the reactive power  $Q$  [Q2]
- Determine the magnitude of the apparent power  $S$  [Q3]

Below the question, there's a table for 'Details zur Frage' (Question Details) with columns for DS, Werte, EH, Pkt., Proz., Maxima, EH, Mode, Tol., Lösung, and Erg / Info.

DS	Werte	EH	Pkt.	Proz.	Maxima	EH	Mode	Tol.	Lösung	Erg / Info
U	import:240,240,220 V		Q0	1.0	100	$\varphi$	CALCUI	1.0%		
phi_l	import:30,45,60,90 °		Q1	1.0	100	P	CALCUI	1.0%		
f	import:50,60,75,80 Hz		Q2	1.0	100	Q	var	CALCUI	1.0%	
R	import:100,150,100 Ohm		Q3	1.0	100	S	VA	CALCUI	1.0%	
C	import:118.8,30.63 uF									
iRe	import:2.07846,1.1 A									
iIr	import:1.2,1.13137 A									
iCre	import:-4.47865,-1. A									
iCi	import:7.75726,1.9 A									
iRe	import:-2.40019,-0. A									
iIm	import:8.95726,3.0 A									
iI	import:9.27326,3.2 A									

At the bottom, there are status bars for 'Image-' (RCSeriesCircuit.mnn), 'Rechts' (50), 'Prozent' (100), and 'Eingelegt: krac'.

## Letto + Modelica Example

Test administration ▶ class ▶ subject ▶ test type

The screenshot shows the Modelica Conference software interface. On the left, there's a sidebar with 'Kategorien' (Categories) and 'Online-Tests'. The main area has tabs for 'Fragen Modelica Conference' and 'Fragendetails: Mehrfach-Berechnungsfrage'. The question details tab shows a question about an R-C series circuit with parameters \$U = {U}\$, \$R = {R}\$, \$L = {L}\$, and \$f = {f}\$. It asks for the phase angle \$\varphi\$, active power \$P\$, reactive power \$Q\$, and apparent power \$S\$. Below the question is a table of variables and their values. A preview window on the right shows a circuit diagram with a voltage source \$V\$, a resistor \$R\$, and a capacitor \$C\$ in series.

# Lotto + Modelica Example

## Examples assigned to categories

Kategorien

- Angewandte Mathematik (0|7)
- Antriebstechnik (0|298)
- Automatisierungstechnik (0|2)
- CPE (0|25)
- Elektronik (0|0)
- Energiesysteme (0|527)
- Grundlagen des Maschinenelements
- Informatik (0|0)
- Labor (0|0)
- Mechatronik (0|0)

Online-Tests:

- 2018-19

Vorschau

Frägen Modellica Conference

Fragenname: Neue Mehrfach-Berechnungsfrage

Quellcode

[!IMG0]

An R-C series circuit has the following parameters:  $\$U = \{U\}$ ,  $\$R = \{R\}$ ,  $\$L = \{L\}$ ,  $\$f = \{f\}$

- Determine the phase angle  $\$varphi$  of the impedance [Q0]
- Determine the active power  $\$P$  [Q1]
- Determine the reactive power  $\$Q$  [Q2]
- Determine the magnitude of the apparent power  $\$S$  [Q3]

Plugins

DS	Werte	EH	Details zur Frage						
U	import:240,240,220 V		Q0	1.0	100	phi	CALCU	1.0%	
phil	import:30,45,60,90 °		Q1	1.0	100	P	CALCU	1.0%	
f	import:50,60,75,80 Hz		Q2	1.0	100	Q	var	CALCU	1.0%
R	import:100,150,100 Ohm		Q3	1.0	100	S	VA	CALCU	1.0%
C	import:118.8,30.63 uF								
IRre	import:2.07846,1.1 A								
IRim	import:1.2,1.13137 A								
ICre	import:-4.47865,-1. A								
ICir	import:7.75726,1.9 A								
Ire	import:-2.40019,-0. A								
Im	import:8.95726,3.0 A								
I	import:9.27326,3.2 A								

Maxima

```
S_complex:=P+%i*Q
```

Image- RCseriesCircuit.png Breite: 50 Prozent:

Eingeloggt: krac

## Letto + Modelica Example

Example details ▶ editor ▶ L<sup>A</sup>T<sub>E</sub>Xsupport ▶ variables ▶ units ▶ digits ▶ display format ▶ plugin graphics ▶ input fields

The screenshot shows the Modelica Conference software interface. On the left, there's a sidebar with categories like 'Angewandte Mathematik' (0|0), 'Antriebstechnik' (0|298), 'Automatisierungstechnik' (0|2), 'CPE' (0|25), 'Elektronik' (0|0), 'Energiesysteme' (0|527), 'Grundlagen des Maschinenelements' (0|0), 'Informatik' (0|0), 'Labor' (0|0), and 'Mechatronik' (0|0). Below that is an 'Online-Tests:' section with '2018-19'. The main area has tabs for 'Fragen', 'Modelica', and 'Conference'. A specific question is selected: 'FrageDetails: Mehrfach-Berechnungsfrage'. The question text is: 'An R-C series circuit has the following parameters: \$U = {U}\\$, \$R = {R}\\$, \$L = {L}\\$, \$f = {f}\\$'. It asks for determining the phase angle \$\varphi\$, active power \$P\$, reactive power \$Q\$, and apparent power \$S\$. At the bottom, there's a preview of the circuit diagram (an R-C series circuit) and some code snippets.

# Lotto + Modelica Example

Create plugin ▷ assign maximum points ▷ unit penalty

Screenshot of the LETTO software interface showing a question creation process for a Modelica Conference.

**Kategorien:**

- Angewandte Mathematik (0|7)
- Antriebstechnik (0|298)
- Automatisierungstechnik (0|2)
- CPE (0|25)
- Elektronik (0|0)
- Energiesysteme (0|527)
- Grundlagen des Maschinenelements
- Informatik (0|0)
- Labor (0|0)
- Mechatronik (0|0)

**Online-Tests:**

- 2018-19

**Vorschau:**

**Fragen Modellica Conference:**

**Fragendetails: Mehrfach-Berechnungsfrage**

**Fragenname:** Neue Mehrfach-Berechnungsfrage

**Quellcode:**

[IMG0]

An R-C series circuit has the following parameters: \$U = {U}\$, \$R = {R}\$, \$L = {L}\$, \$f = {f}\$

(a) Determine the phase angle \$\varphi\$ of the impedance [Q0]  
 (b) Determine the active power \$P\$ [Q1]  
 (c) Determine the reactive power \$Q\$ [Q2]  
 (d) Determine the magnitude of the apparent power \$S\$ [Q3]

**Plugins:**

DS	Werte	EH	Details zur Frage					
Q..	Pkt.	Proz.	Maxima	EH	Mode	Tol	Lösung	Erg / Info
Q0	1.0	100	phi	CALCUL	1.0%			
Q1	1.0	100	P	CALCUL	1.0%			
Q2	1.0	100	Q	var	CALCUL	1.0%		
Q3	1.0	100	S	VA	CALCUL	1.0%		

**Maxima:**

```
S_complex:=P+%i*Q
```

# Lotto + Modelica Example

## Define or import data sets

**Kategorien**

- Angewandte Mathematik (0|7)
- Antriebstechnik (0|298)
- Automatisierungstechnik (0|2)
- CPE (0|25)
- Elektronik (0|0)
- Energiesysteme (0|527)
- Grundlagen des Maschinenbaus

  - Informatik (0|0)
  - Labor (0|0)
  - Mechatronik (0|0)

**Online-Tests:**

- 2018-19

**Vorschau**

The circuit diagram shows a series connection of a voltage source  $V$ , a resistor  $R$ , and a capacitor  $C$ .

**Fragen Modellica Conference**

**Fragendetails: Mehrfach-Berechnungsfrage**

**Fragenname:** Neue Mehrfach-Berechnungsfrage

**Quellcode**

[!IMG0]

An R-C series circuit has the following parameters:  $\$U = \{U\}$ ,  $\$R = \{R\}$ ,  $\$L = \{L\}$ ,  $\$f = \{f\}$

- Determine the phase angle  $\$varphi$  of the impedance [Q0]
- Determine the active power  $\$P$  [Q1]
- Determine the reactive power  $\$Q$  [Q2]
- Determine the magnitude of the apparent power  $\$S$  [Q3]

**Plugins**

DS	Werte	EH
U	import:240,240,220 V	
phi	import:30,45,60,90 °	
f	import:50,60,75,80 Hz	
R	import:100,150,100 Ohm	
C	import:118.8,30.63 uF	
IRre	import:2.07846,1.1 A	
IRirr	import:1.2,1.13137 A	
ICre	import:-4.47865,-1 A	
ICin	import:7.75726,1.9 A	
Ire	import:-2.40019,-0 A	
Im	import:8.95726,3.0 A	
I	import:9.27326,3.2 A	

Q.	Pkt.	Proz.	Maxima	EH	Mode	Tol	Lösung	Erg / Info
Q0	1.0	100	phi		CALCU	1.0%		
Q1	1.0	100	P		CALCU	1.0%		
Q2	1.0	100	Q	var	CALCU	1.0%		
Q3	1.0	100	S	VA	CALCU	1.0%		

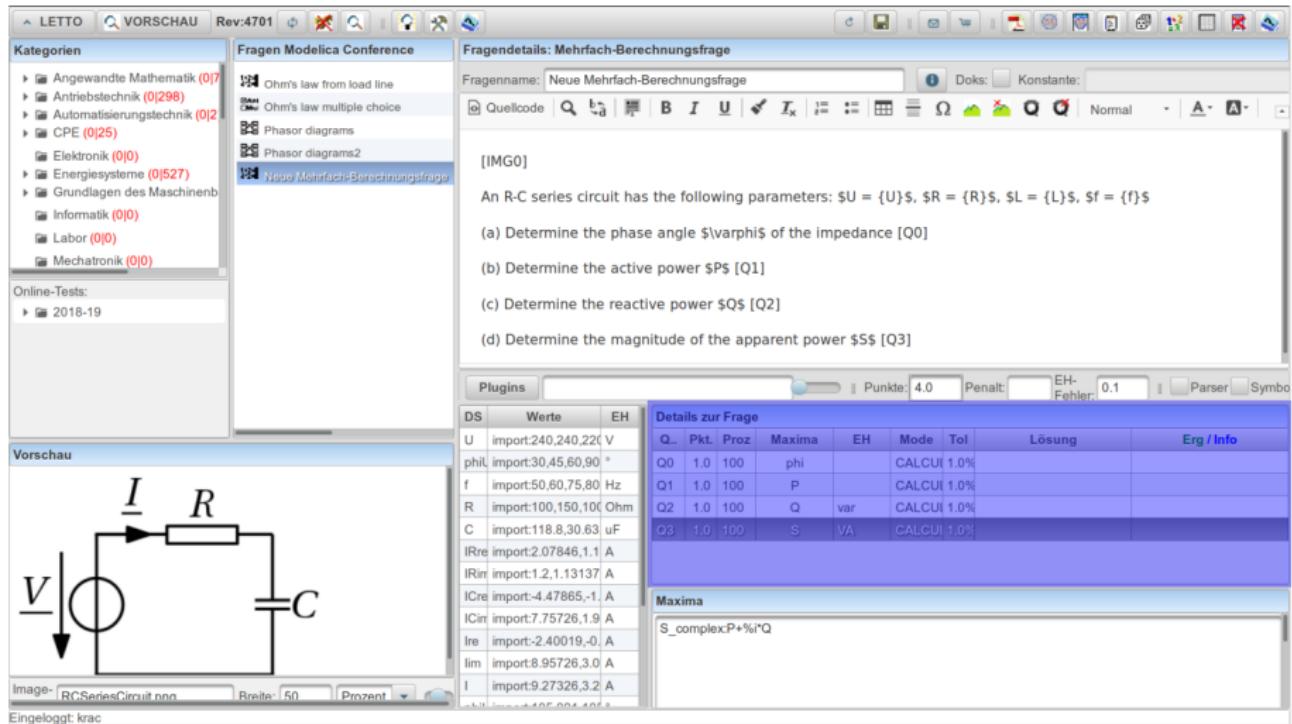
**Details zur Frage**

**Maxima**

```
S_complex:P+%i*Q
```

# Lotto + Modelica Example

Answer details ▷ Maxima result ▷ target unit ▷ result accuracy ▷ question type ▷ hints



The screenshot shows the LETTO software interface. On the left, there's a sidebar with categories like "Angewandte Mathematik (07)", "Antriebstechnik (0|298)", etc., and an online test from 2018-19. The main area displays a question about an R-C series circuit. Below the question is a table of parameters and results, and a "Maxima" section.

**Question:**

An R-C series circuit has the following parameters:  $U = \{U\}$ ,  $R = \{R\}$ ,  $L = \{L\}$ ,  $f = \{f\}$ .

- Determine the phase angle  $\varphi$  of the impedance [Q0]
- Determine the active power  $P$  [Q1]
- Determine the reactive power  $Q$  [Q2]
- Determine the magnitude of the apparent power  $S$  [Q3]

**Table of Parameters and Results:**

DS	Werte	EH
U	import:240,240,220 V	
phi	import:30,45,60,90 °	
f	import:50,60,75,80 Hz	
R	import:100,150,100 Ohm	
C	import:118,8,30,63 uF	
IRe	import:2.07846,1,1 A	
IRin	import:1,2,1,13137 A	
ICre	import:-4.47865,-1, A	
ICin	import:7.75726,1,9 A	
Ir	import:-2.40019,-0, A	
Im	import:8.95726,3,0 A	
I	import:9.27326,3,2 A	

**Maxima:**

```
S_complex:=P+%iQ
```

# Lotto + Modelica Example

## Maxima code ▷ post processing

LETTO VORSCHAU Rev:4701

Kategorien

- Angewandte Mathematik (0)
- Antriebstechnik (0|298)
- Automatisierungstechnik (0|2)
- CPE (0|25)
- Elektronik (0|0)
- Energiesysteme (0|527)
- Grundlagen des Maschinenelements
- Informatik (0|0)
- Labor (0|0)
- Mechatronik (0|0)

Online-Tests:

- 2018-19

Vorschau

Details zur Frage

DS	Werte	EH					
U	import:240,240,220 V						
phi	import:30,45,60,90 °	*					
f	import:50,60,75,80 Hz						
R	import:100,150,100 Ohm						
C	import:118.8,30.63 uF						
IRre	import:2.07846,1.1 A						
IRirr	import:1.2,1.1,13137 A						
ICre	import:-4.47865,-1. A						
ICirr	import:7.75726,1.9 A						
Ire	import:-2.40019,-0. A						
Im	import:8.95726,3.0 A						
I	import:9.27326,3.2 A						

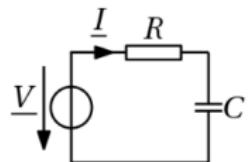
Maxima

```
S_complex:P+%i*Q
```

Image- RCseriesCircuit.mnc Breite: 50 Prozent: Eingeloggt: krac

# Lotto + Modelica Example

## Preview | Student mode



An R-C series circuit has the following parameters  $U = 240 \text{ V}$ ,  $R = 100 \Omega$ ,  $C = 118.8 \mu\text{F}$ ,  $f = 50 \text{ Hz}$

- (a) Determine the phase angle  $\varphi$  of the impedance
- (b) Determine the active power  $P$
- (c) Determine the reactive power  $Q$
- (d) Determine the magnitude of the apparent power  $S$

Ergebnisauswertung:

Prüfen

Zurücksetzen

# Lotto Grading

## Exercise results

### Ergebnisse Drehstromsysteme 7.2

[Zurück](#)[Neu Bewerten](#)[Ergebnis-Eingabe](#)[Statistik](#)[Bp.Nr.](#)

Name	Versuch		Punkte	Note	Fr. 1 1.0	Fr. 2 1.0	Fr. 3 3.0	Fr. 4 3.0	Fr. 5 3.0	Fr. 6 5.0	Fr. 7 5.0	Fr. 8 5.0	Fr. 9 5.0	Fr. 10 5.0	Fr. 11 5.0
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		offen	---	1.00	1.00	---	---	---	5.00	---	5.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		offen	----	----	----	----	----	----	5.00	----	5.00	----	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		39.0/41.0 -- 95.1%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	3.00
	12-2-2019		offen	----	1.00	1.00	3.00	3.00	3.00	2.00	2.00	0.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00
	12-2-2019		41.0/41.0 -- 100.0%	Sehr Gut	1.00	1.00	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00

# Lotto Grading

## Individual exercise results

### Fr. 11 (Bp.: 1)

( 3.0 / 5.0 ) Teilweise Richtig

Punkte ändern:

Q0: 1.00	Q1: 1.00	Q2: 1.00	Q3: 1.00	Q4: 1.00	$\Sigma$ : 3.00
1	1	0	0	1	3.00

[Frage bearbeiten](#)

Individuelles Feedback:

  
[Neu Beurteilen](#) [↓](#) [↑](#) [←](#) [→](#) [Schließen](#)

Von ein symmetrischen Drehstromsystem (Rechtssystem) kennt man die Außenleiterspannung  $U_{23} = 390 \text{ V} \angle 165^\circ$ .

(a) Bestimmen Sie die Außenleiterspannung  $U_{31} = U_{3N} - U_{1N}$  390V arg-195° ✗ (390 V  $\angle 45^\circ$ )

(b) Bestimmen Sie die Außenleiterspannung  $U_{12} = U_{1N} - U_{2N}$  390V arg45° ✗ (390 V  $\angle -75^\circ$ )

(c) Bestimmen Sie die Sternspannung  $U_{1N}$  225.2V arg255° ✓ (225.17 V  $\angle -105^\circ$ )

(d) Bestimmen Sie die Sternspannung  $U_{2N}$  225.2V arg135° ✓ (225.17 V  $\angle 135^\circ$ )

(e) Bestimmen Sie die Sternspannung  $U_{3N}$  225.2V arg15° ✓ (225.17 V  $\angle 15^\circ$ )

# Letto Grading

## Individual exercise results

### Ergebnisauswertung:

#### Antworten:

Zeit	Eingabe	Bewertung
12-2-2019 12:49:08	225.2V arg255°225.2V arg135°390V arg-195°390V arg45°225.2V arg15°	3.0 / 5.0
12-2-2019 12:18:30	225.2V arg255°225.2V arg135°390V arg-195°390V arg45°	4.0 / 5.0
12-2-2019 12:17:35	225.2V arg255°390V arg-195°390V arg45°	3.0 / 5.0
12-2-2019 12:17:11	225.2V arg135°390V arg-195°390V arg45°	2.0 / 5.0
12-2-2019 12:14:37	225.2V arg150°390V arg-195°390V arg45°	2.0 / 5.0
12-2-2019 12:14:21	225.2V arg15°390V arg-195°390V arg45°	2.0 / 5.0
12-2-2019 12:11:38	390V arg-195°390V arg45°	2.0 / 5.0
12-2-2019 12:10:31	390V arg-195°390V arg75°	1.0 / 5.0
12-2-2019 12:09:57	390V arg-195°390V arg-75°	1.0 / 5.0
12-2-2019 12:08:32	390V arg-195°	1.0 / 5.0
12-2-2019 12:08:20	390V arg-75°	0.0 / 5.0
12-2-2019 12:07:59	390V arg-85°	0.0 / 5.0
12-2-2019 12:07:37	390V arg285°	0.0 / 5.0
12-2-2019 12:07:19	390V arg45°	0.0 / 5.0

# Lotto

## Learning

- Consider different learning styles
  - ▶ Individual
  - ▶ Group
  - ▶ Sharing
- Repetitive exercises
- Evaluation
- Grading

# Table of Contents

- 1 Online Quiz
- 2 Modelica Book
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- 5 Virtual Modelica Lab
- 6 Conclusions

# Virtual Modelica Lab

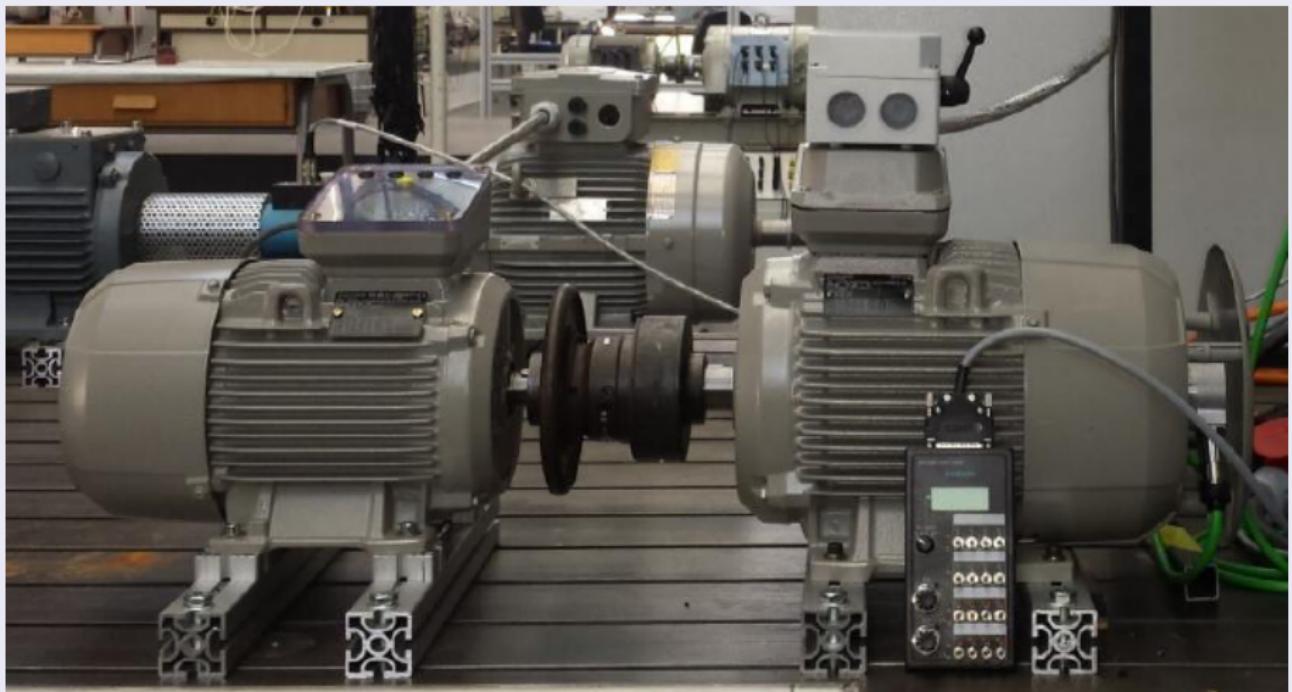
## Virtual lab objectives

- Demonstration of practical applications
- Deepening of theoretical knowledge
- Preparation studies prior to lab exercise
- Compensation exercise in case of lab absence

Work performed by Michael Obermeier @ OTH Regensburg  
Supervised by Prof. Anton Haumer

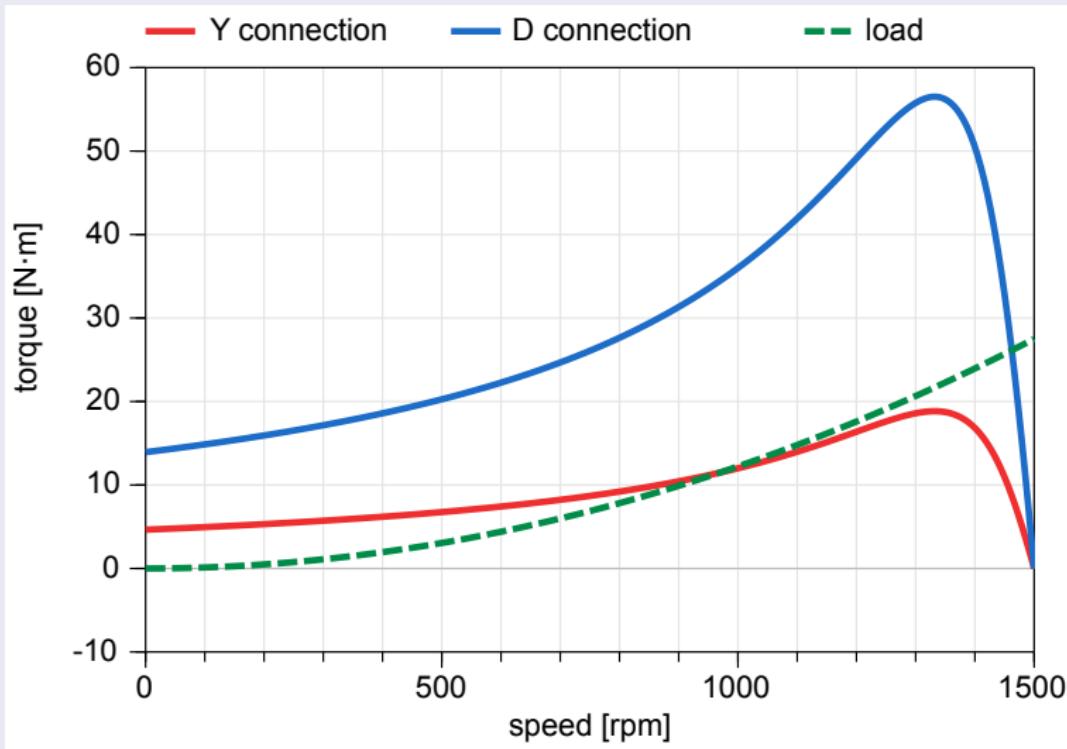
# Virtual Modelica Lab

## Lab setup



# Virtual Modelica Lab

## Machine characteristics



# Virtual Modelica Lab

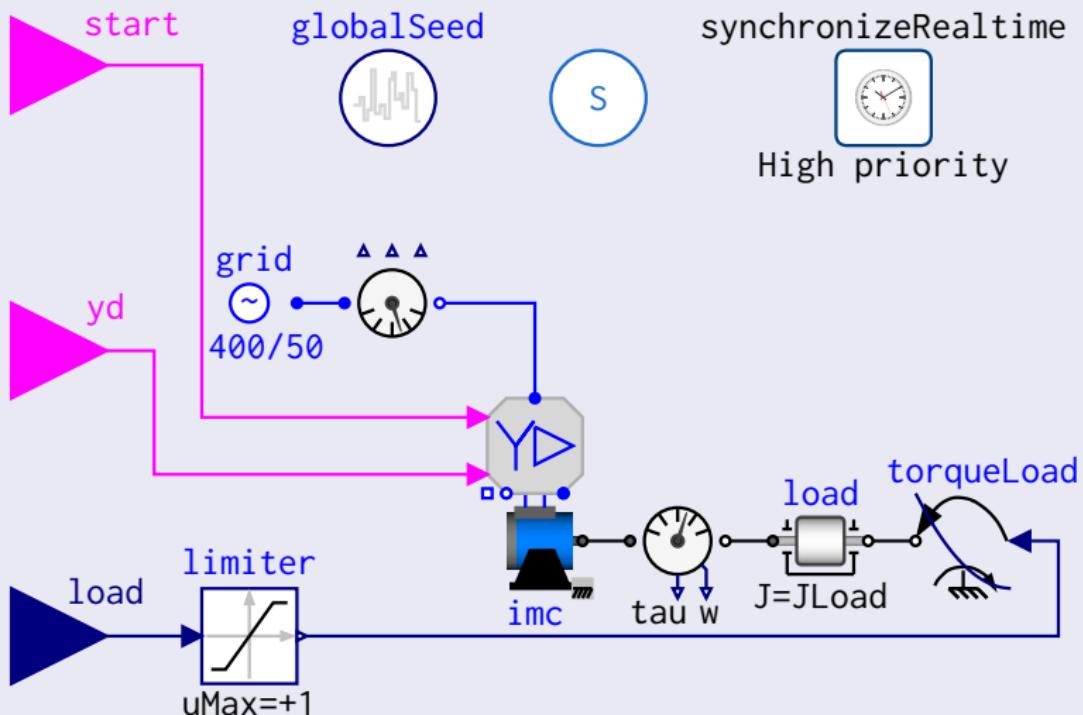
## Tool chain



- Modelica tool
- Labview
- MoBA Simulator (TLK-Thermo GmbH)

# Virtual Modelica Lab

## Functional mockup unit (FMU)



# Virtual Modelica Lab

## Key Performance Indicators

- Modelica\_DeviceDrivers ~ realtime
- Add measuring noise
- Labview
  - ▶ control buttons
  - ▶ scope graphs

# Virtual Modelica Lab

## Outlook

- Development of additional
  - ▶ input
  - ▶ outputinterfaces
- Standalone application (license)
- Web access to National Instruments Virtual Instrument

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# Conclusions

- Online Kahoot quiz
- Modelica Book
- Introduction to Letto
  - ▶ Features
  - ▶ Selected examples
  - ▶ Grading
- Virtual Modelica Lab
  - ▶ Objectives plus implementation
  - ▶ Live demonstration

# Thank you for your attention

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## Evaluation of results

CheckNext questionReset

**Assessment:** Points: 1.00 / 1.00

Correct