

# Co-creating interactive online exercises

Annoesjka Cabo





# The Netherlands: Delft University of Technology



# Delft University of Technology





# TU Delft

8 Engineering Faculties

25.000 students

1900 fte scientific staff

2000 fte PhD students





# Annoesjka Cabo



Associate Professor in Statistics  
Delft Institute of Applied Mathematics  
Director of Studies: Interfaculty Education



# Mathematics at TU Delft

Delft Institute of Applied Mathematics @ Faculty EEMCS

*Mathematics programme: 550 students*    Interfaculty education: 15.000 students  
20 fte    48 fte: 23 fte dedicated lecturers





PRIME

PRIME

=

PRogramme of Innovation in Mathematics Education

<https://www.tudelft.nl/ewi/over-de-faculteit/afdelingen/applied-mathematics/education/prime/>

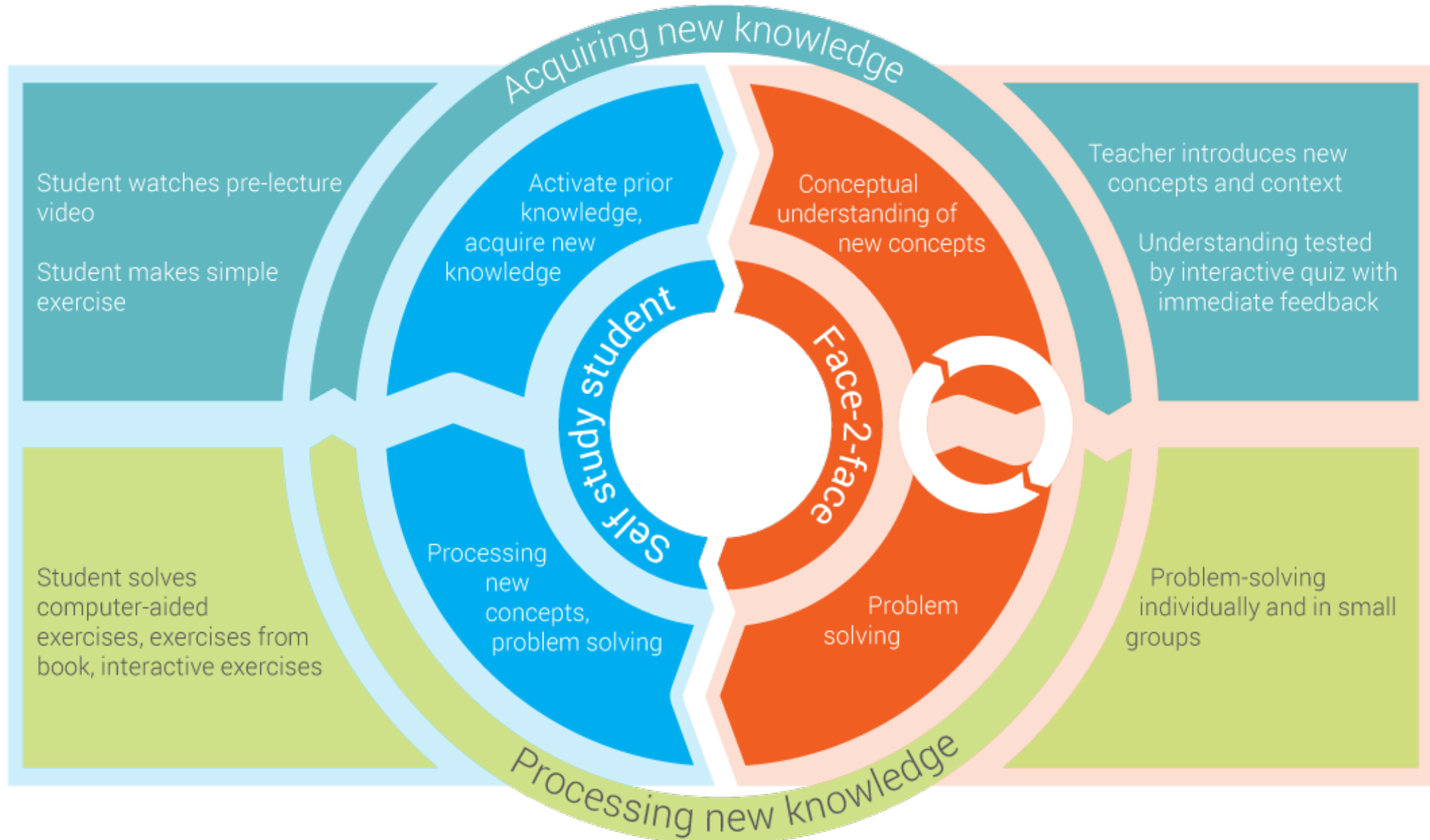




# Goals

- Activate students
- Transfer mathematics to engineering
- Efficiency of teaching and learning

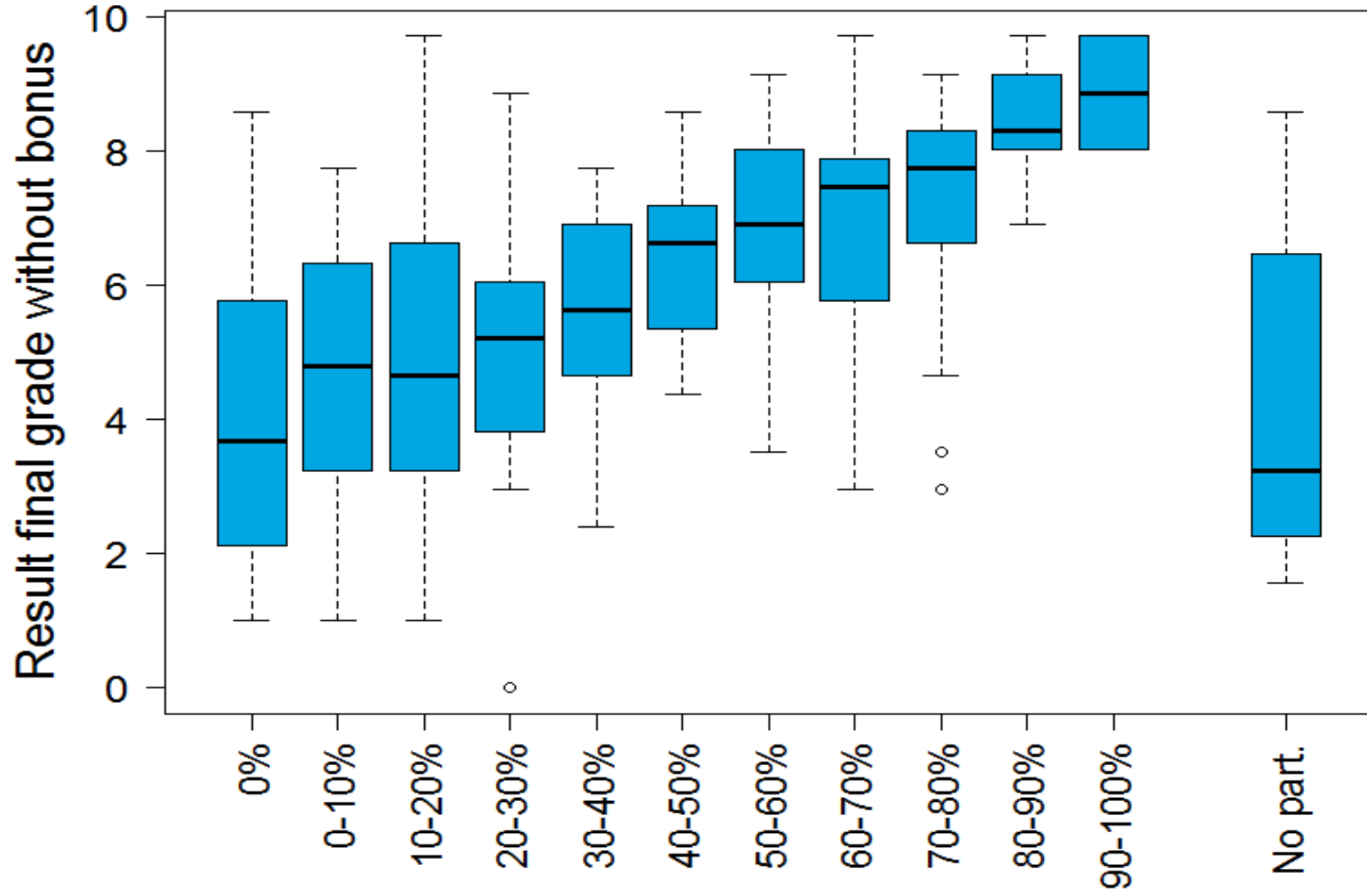
# Didactical concept: Prepare, Participate, Practice





Practice

# Results





# Existing online platform

## Advantages

- Nice interface
- Good feedback options
- Statistics

## Disadvantages

- Expensive
- Not aligned with the book
- Exercises developed by staff lacked functionalities

# Need for a new online platform

## Challenges

1. Content
2. Maintenance and support

## Solutions

1. Use existing content from lecturers
2. Work together with an existing platform



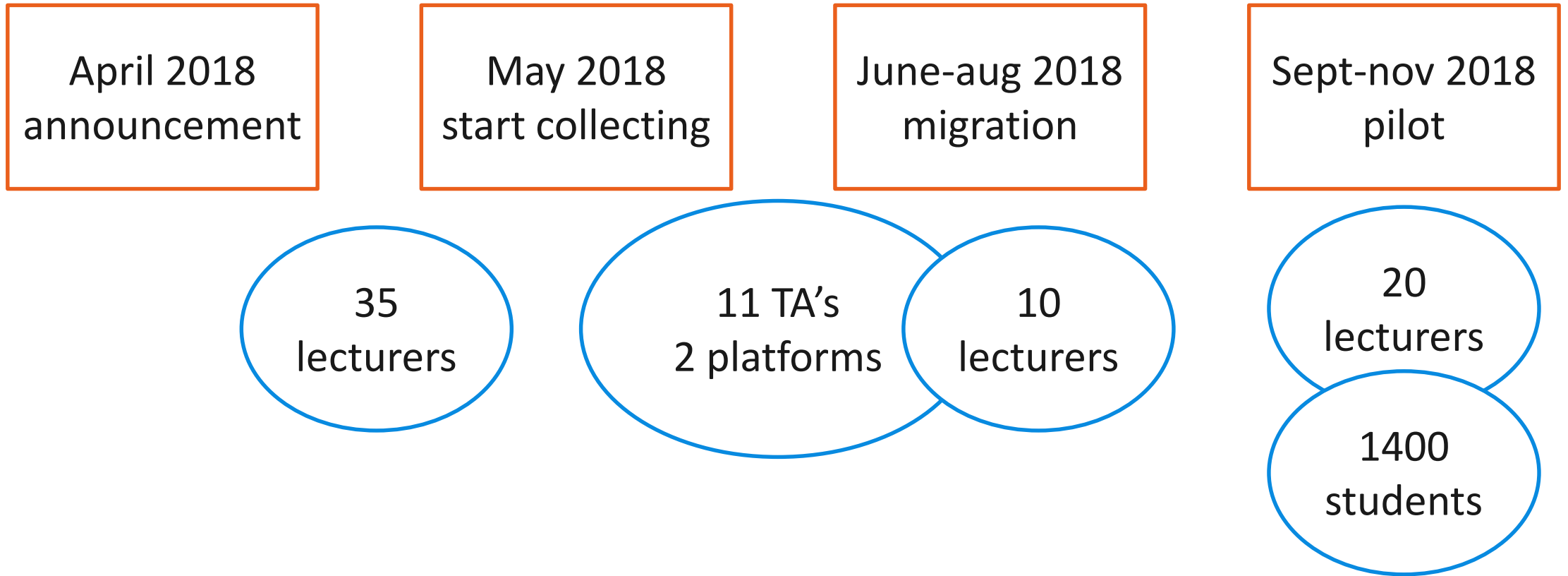
Content

# Courses

## Calculus I:

- differential equations (linear, separable, 2nd order)

# Collection





1	Onderwerpen Analyse					Low priority	Currently not
2	Hoofdonderwerp	Subonderwerp	Stewart (8)	Adams (8)	Openstax	Onderwerpen	
3	Differentiation	Inverse functions	1.5		1.1.4	* Abstract inve	Logaritme (re
4							
5	Limits	Limits of functions	2.2		1.2.2	* Abstracte vra	*Standaardlin
6	Limits	Calculating limits	2.3		1.2.3	*Rekenregels	*Opgaven me
7	Limits	Continuity	2.5		1.2.4	*Bepalen of fu	*Bepalen cor
8	Limits	Limits at infinity	2.6		1.4.6	*Wegdelen hoc	*Horizontale
9							
10	Differentiation	Chain rule	3.4		1.3.6		
11	Differentiation	Implicit Differentiation	3.5		1.3.8	*Bepalen of im	*Impliciet afg
12	Differentiation	Linearization	3.10		1.4.2	*Linearisering	*Functie ben
13	Differentiation	Hyperbolic functions	3.11		1.1.5		
14							
15	Limits	l'Hopital	4.4		1.4.8	* Hopital in bre	*Meerdere ke
16							
17	Integration	Fundamental Theorem of Calculu	5.3		2.1.3	*afgeleide van	* Integraal va
18	Integration	Substitution	5.5		2.1.5	*Substitueer u	*Substitueer
19							
20	Integration	Integration by parts	7.1		2.3.1	*Basis part int	*Herhaald pa
21	Integration	Partial fractions	7.4		2.3.4	*Breuksplitsen	*Noemer gra
22	Integration	Improper integrals	7.8		2.3.7	*Type I (int_a^	*Type II (int_;
23							
24	ODE1	Modelling with ODE	9.1		2.4.1	*Opstellen DV	*Interpreterer
25	ODE1	Direction Field	9.2		2.4.2	*Plaatje matchen met dv	
26	ODE1	Euler Method	9.3		2.4.3		

# Courses

Calculus II, III:

- functions of severable variables
- vector calculus

# Courses

Linear algebra (Lay)

Probability and Statistics

Differential equations (Boyce and DiPrima)



Selection

# Selection of the platform

Pilot with three existing platforms,  
using different CAS  
(Maple, Maxima, Python)

# Criteria

1. User experience lecturers
2. User experience students
3. Open content
4. Integration in LMS
5. Support
6. Costs



And the winner is

<https://grasple.com/math/>



And the winner is

Open Education Award 2019



# Integration

## Integration in the Learning Management System (D2L, Brightspace)

The screenshot displays a web-based learning management system interface. At the top, there is a navigation bar with links for "Course Home", "Content", "Grades", "Course Admin", and "Help". Below this, a breadcrumb trail shows "Table of Contents > Statistics > Lecture 9: Central limit theorem > Calculus - Lecture 1". The main content area is titled "Calculus - Lecture 1" and features a "CHALLENGES" section with a progress indicator "0/1" and an "edit" button. A "Report mistake!" link is also visible. The question, labeled "QUESTION - TRY 2 OF 3", asks for the derivative of  $H(x) = \sqrt{x^2 + 1}$ . A "SKIP" button is present. The solution is provided in a large orange box with four steps: 1. Using the chain rule with  $F(x) = f(g(x))$ ,  $g(x) = x^2 + 1$ , and  $f(x) = \sqrt{g(x)}$ . 2. The derivative of  $f(g(x))$  is  $f'(g(x)) = \frac{1}{2\sqrt{g(x)}}$ . 3. The derivative of  $g(x)$  is  $g'(x) = 2x$ . 4. The final derivative is  $F'(x) = f'(g(x)) \cdot g'(x) = \frac{1}{2\sqrt{x^2+1}} \cdot 2x = \frac{x}{\sqrt{x^2+1}}$ . A "powered by Graspie" watermark is at the bottom left, and a chat icon is at the bottom right.

Course Home Content Grades Course Admin Help

Table of Contents > Statistics > Lecture 9: Central limit theorem > Calculus - Lecture 1

### Calculus - Lecture 1

CHALLENGES 0/1 edit Report mistake!

QUESTION - TRY 2 OF 3 SKIP

$H(x) = \sqrt{x^2 + 1}$

What is the derivative of  $H(x)$ ?

You skipped the question. Study the correct answer below such that you can answer this question next time!

1. We use the chain rule. Take  $F(x) = f(g(x))$ . With  $g(x) = x^2 + 1$  and  $f(x) = \sqrt{g(x)}$ .
2. The derivative of  $f(g(x))$  is  $f'(g(x)) = \frac{1}{2\sqrt{g(x)}}$
3. The derivative of  $g(x)$  is  $g'(x) = 2x$
4.  $F'(x) = f'(g(x)) \cdot g'(x) = \frac{1}{2\sqrt{x^2+1}} \cdot 2x = \frac{x}{\sqrt{x^2+1}}$

powered by Graspie



Basic math exercises have been created by [OpenStax](#). The more advanced topics (Calculus) have been created by [Delft University of Technology](#) and are adapted by Grasple. Most materials are CC licensed and the rest will be released with a CC license in the coming months. Feel free to reuse, remix and redistribute these exercises as long as you make a proper attribution.

## Legend



Indicates whether a lesson/explanation is available per subject



10

Indicates if and how many exercises are currently available per subject



Content has an open Creative Commons license



Content will be released with an open Creative Commons license in the near future

## Basis

- [Algebraic expressions](#)
- [Exponents](#)
- [Square roots](#)
- [Polynomials and factoring polynomials](#)
- [Rational expressions](#)
- [Solving equations](#)
- [Inequalities](#)



5



5



5



5



3



3



3



## Functions and graphs

- [Graphs](#)
- [Functions](#)
- [Transformation of functions](#)
- [Inverse functions](#)
- [Composition of functions](#)



5



10



3



5



5



- [Tangent lines](#) ⚡ 7 ©
- [Increase and decrease of functions](#) ⚡ 5 ©
- [Extreme values](#) ⚡ 5 ©
- [Concavity of functions](#) ⚡ 5 ©
- [Inflection points](#) ⚡ 5 ©
- [Optimizations](#) ⚡ 5 ©
- [Other applications of derivatives](#) ⚡ 5 ©

- [Vector Dot Product](#) ⚡ 7 ©
- [Vector Cross Product](#) ⚡ 7 ©

## Inverse Functions

- [Inverse Function](#) ⚡ 5 ©
- [Inverse Trigonometric Functions](#) ⚡ 5 ©

## Implicit Differentiation

- [The Chain rule](#) ⚡ 20 ©
- [Implicit Differentiation](#) ⚡ 16 ©

## Linear Approximations and Differentials

- [Linearization](#) ⚡ 11 ©


## L'Hopital's Rule

- [L'Hospital's Rule](#) ⚡ 11 ©



## Functions: Inverse Trigonometric Functions


**⚡ Exercises** - Click to see exercises

14642 Math - Equation 

Give exact answers.

\_\_\_\_\_


$$\sin \left( \arctan \left( \frac{[!numer1!]}{[!denom1!]} \right) \right) =$$

14644 Math - Equation 

Give exact answers.

\_\_\_\_\_


$$\arcsin \left( \frac{[!x1!]}{2} \sqrt{[!p!]} \right) =$$

14647 Math - Equation 

Give exact answers.

\_\_\_\_\_

$$\sin \left( \arccos \left( \frac{[!a!]}{[!an!]} \right) \right) =$$

14650 Math - Equation 

Give exact answers.

\_\_\_\_\_

$$\arcsin \left( \sin \left( \frac{[!a!]}{[!an!]} \pi \right) \right) =$$

14653 Math - Equation 

Give exact answers.

Want to see more exercises?



EXERCISE



Review mode

suggest improvement

QUESTION 1

SKIP

Give exact answers.

$$\sin\left(\arctan\left(\frac{6}{1}\right)\right) =$$

Calculator toolbar for Question 1 containing: fraction, multiplication, square, square root, nth root, pi, and e.

Check my answer

Calculator toolbar for Question 1 containing: Greek letters, trigonometric functions, calculus symbols, factorial, logarithm, and matrix.

QUESTION 2

SKIP

$$\cos\left(\arctan\left(\frac{-6}{9}\right)\right) =$$

Calculator toolbar for Question 2 containing: fraction, multiplication, square, square root, nth root, pi, and e.



Future

# Where are we?

For all courses sufficient number of exercises available  
Challenge: linear algebra and diff equations

# What's next?

- Improve feedback
- Scaffolding
- Use for testing?
- Statistics
- Learning analytics

# Co-creating interactive online exercises

