KOÇ UNIVERSITY

COMP301

Programming Languages Concepts

Prof. T. Metin Sezgin

Outline

- Introduction
  - Course Description
  - Course Objectives
  - Learning Outcomes
- Syllabus
- Teaching Assistants
- Grading
  - Quiz
  - Project
  - Participation
- Problem Sessions

Introduction / Course Description

Programming languages (i.e. C++, Java, Ada, Lisp, ML, Prolog) concepts and paradigms. Syntax, semantics. Abstraction, encapsulation, type systems, binding, run-time storage, sequencers, concurrency, control. Providing examples from functional, object-oriented and logic programming paradigms.

Fun quiz activity – Are you qualified to take this class?

Please login

Fun poll activity

What kinds of programming paradigms are you familiar with?

Fun quiz activity #1

What output does the following generate?

```
def create_adder(x):
    tic = x

    def adder():
        tic = tic + 1
        return tic

    return adder



fun_a = create_adder(0)
fun_b = create_adder(0)

print(fun_a(), fun_b(), fun_a(), fun_b())
```

Fun quiz activity #2

What output does the following genera

```
def create_adder(x):
    tic = x

    def adder():
        nonlocal tic
        tic = tic + 1
        return tic

    return adder


fun_a = create_adder(0)
fun_b = create_adder(0)

print(fun_a(), fun_b(), fun_a(), fun_b())
```

Fun quiz activity #3

What output does the following genera

```
def create_adder(x):
    global tic
    tic = x

    def adder():
        nonlocal tic
        tic = tic + 1
        return tic

    return adder


fun_a = create_adder(0)
fun_b = create_adder(0)

print(fun_a(), fun_b(), fun_a(), fun_b())
```

Fun quiz activity #4

What output does the following genera

```
def create_adder(x):
    global tic
    tic = x

    def adder():
        global tic
        tic = tic + 1
        return tic

    return adder


fun_a = create_adder(0)
fun_b = create_adder(0)

print(fun_a(), fun_b(), fun_a(), fun_b())
```

Introduction / Course Objectives

Teaching core programming concepts including data representation, procedural representation, grammars, environment models, parsing, evaluation, parameter passing, continuation passing, functional programming.

Introduction / Learning Outcomes

Students taking this class will gain fluency in core programming concepts including data representation, procedural representation, grammars, environment models, parsing, evaluation, parameter passing, continuation passing.

Syllabus

1. **Functional programming**
   a. Recursive programming
   b. Anonymous functions
   c. Constructors, accessors
   d. Scheme
   e. Data scructures
2. **Inductive Sets of Data**
   a. Recursively Specified Data
   b. Deriving Recursive Programs
   c. Auxiliary Procedures and Context Arguments
3. **Data Abstraction**
   a. Specifying Data via Interface
   b. Representation Strategies for Data Types
   c. Interface for Recursive Data Types
   d. A Tool for Defining Recursive Data
4. **Expressions**
   a. Specification and Implementation Strategy
   b. LET: A Simple Language
   c. PROC: A Language with Procedures
   d. LETREC: A Language with Recursive Procedures
   e. Scoping and Binding of Variables
   f. Eliminating Variable Names
   g. Implementing Lexical Addressing
5. **Continuation-Passing Interpreters**
   a. A Continuation Passing Interpreter
   b. A Trampolined Interpreter

Syllabus

These subjects are from the books:

"Structure and Interpretation of Computer Programs" by *Gerald Jay Sussman, Hal Abelson*

"Essentials of Programming Languages" 3rd. ed. by *Friedman* and *Wand*.

Please find the books at:
http://www.eopl3.com/ and
http://mitpress.mit.edu/sites/default/files/sicp/full-text/book/book.html

What is Language?

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lan·guage *noun* \laŋ-gwij, -wij\

Definition of LANGUAGE

1 **a :** the words, their pronunciation, and the methods of combining them used and understood by a community

b (1) **:** audible, articulate, meaningful sound as produced by the action of the vocal organs (2) **:** a systematic means of communicating ideas or feelings by the use of conventionalized signs, sounds, gestures, or marks having understood meanings (3) **:** the suggestion by objects, actions, or conditions of associated ideas or feelings *<language* in their very gesture — Shakespeare> (4) **:** the means by which animals communicate (5) **:** a formal system of signs and symbols (as FORTRAN or a calculus in logic) including rules for the formation and transformation of admissible expressions (6) **:** MACHINE LANGUAGE 1

2 **a :** form or manner of verbal expression; *specifically* **:** STYLE

b : the vocabulary and phraseology belonging to an art or a department of knowledge

c : PROFANITY

3 **:** the study of language especially as a school subject

4 **:** specific words especially in a law or regulation

Why study programming languages?

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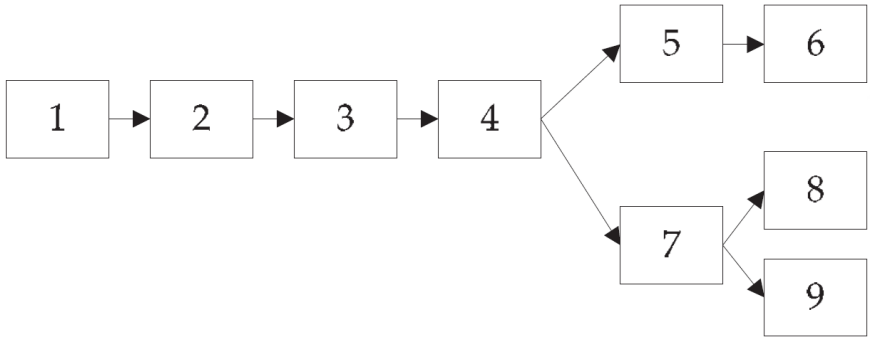
- This class is not about
  - A particular programming language
  - Programming
  - Software engineering
  - Writing better code
- This class is about
  - Programming languages concepts
    - Data representation, recursion, binding
    - Control, state, parameter passing, scoping
    - Interpreters, compilers
  - Themes that span many languages
    - Some practical, some not so practical
  - Defining new languages
  - Learning new languages faster!
- This class is a Meta-Class

Organization of the course (textbook)

- SICP Chapter 1: Building abstractions with procedures
- SICP Chapter 2: Building abstractions with data
- EOPL Chapter 1: Recursive data & recursive programming
- EOPL Chapter 2: Data types, abstraction
- EOPL Chapter 3: Interpreters
- EOPL Chapter 4: State, parameter passing
- EOPL Chapter 5: Control, trampolining, exceptions
- EOPL Chapter 6: CPS conversion
- EOPL Chapter 7: Type checking, reconstruction
- EOPL Chapter 8: Modules
- EOPL Chapter 9: Object Oriented Programming



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Details of the Syllabus

Important changes to the class

- Completely revamped
- Delivery
  - Revised for online delivery
  - The concept of “nuggets” or “pills”
  - Tight connection to a set of learning outcomes

Important changes to the class

* Understand Functional Programming
* Specify sets and data using bottom-up, top-down, rules of inference
* Understand the differences between these specification
* Understand and use BNF notation
* Create recursive programs that operate on recursive data
* Understand the basic principles for implementing procedures operating on recursively defined data
* Specify data using define-datatype or equivalent
* Manipulate data using the cases statement or equivalent
* Understand data-structure and procedural representation of data
* Understand concepts such as constructors, extractors, observers predicates
* Understand and use formal notation for representation
* Understand abstract and concrete syntax
* Draw AST for given expressions
* Understand the concept of behavior specification
* Understand the difference between implementation and interface definition
* Understand the concepts of expressed, and denoted values
* Understand behavior specification for the LET, PROC, LETREC and EREF languages
* Understand the pipeline that leads from lexical analysis to machine code
* Understand the basic interpreter recipe and use it to build interpreters
* Write interpreters for these languages
* Understand the implementation of procedures and procedure application
* Understand how recursive procedures can be implemented in an interpreter
* Extend these languages with new expressions and features
* Be able to specify the behavior of new expressions using formal notation
* Implement new features
* Understand the concept of scope, and variants such as dynamic and static scoping

* Know the concepts of declaration and reference
* Be able to write a simple translator
* Be able to draw contour diagrams and match references to declarations
* Understand lexical addressing, and find lexical depths
* Be able to perform lexical conversion (lexical addressing)
* Understand the concept of state and how a state-less language differs from one with effects
* Understand the purpose of the environment and the store
* Understand the implementation of store for implicit and explicit references

MIDTERM

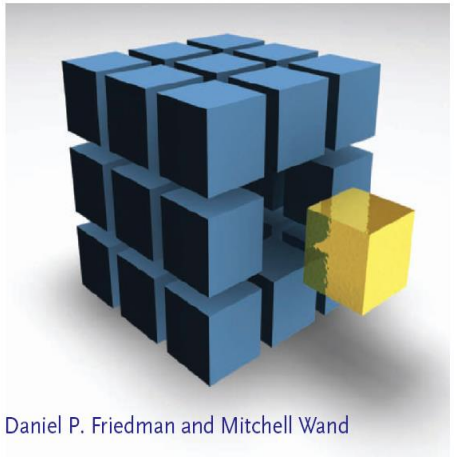
* Understand how pairs can be implemented, and do so
* Explain why the second implementation is more efficient
* Implement more sophisticated data structures (e.g., stack, arrays).
* Understand that there are variations to parameter passing
* Understand CBV/CBR and how they work
* Understand the uses of CBR
* Trace and CBV/CBR evaluation using the env & store
* Implement CBR/CBR
* Understand the philosophy of lazy evaluation
* Understand call by need and call by name and how they work
* Understand the uses of lazy evaluation
* Trace and CBNeed CBName evaluation using the env & store
* Implement CBNeed CBName
* Understand the difference between tail-recursion & recursion
* Understand the concept of continuation
* Implement simple procedures using continuations (e.g., pow, fact, fib)
* Understand how the concept of continuations can be applied to implement an interpreter
* Implement an interpreter using continuations

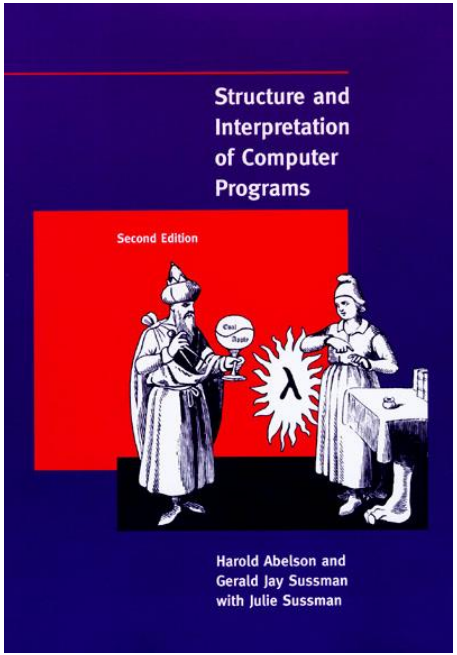
FINAL

Important changes to the class

- Complete revamped
- Delivery
  - Revised for online delivery
  - The concept of “nuggets” or “pills”
  - Tight connection to a set of learning outcomes
- TA support
  - Extremely happy to have strong TA support
  - All class activities revised
- Assessment exercises
  - Completely revised
  - Project component added
  - Group work added

The Textbook





Errata:
http://www.eopl3.com/errata.html

Teaching Assistants

Shadi Hamdan
shamdan17@ku.edu.tr
Office Hour: TBD

- Computer Science PhD Student at Koç University
- Working on End to End Autonomous Driving with transformers
- KU alumni

Nazir Nayal
nnayal17@ku.edu.tr

Office Hour: TBD

- Computer Science M.Sc. Student at Koç University
- Interested in Chess, Anime and Competitive Programming
- Working on Computer Vision, Few-Shot Learning and Rare Events Detection in Autonomous Driving

Teaching Assistants

Diğdem Yıldız
digdemyildiz19@ku.edu.tr
Office Hour: TBD

- Electrical & Electronics Engineering Student at Koç University
- Pursuing Double Major with Computer Engineering
- Interested in tennis, yoga, painting, poetry

Fatma Ceren Tarım
ftarim19@ku.edu.tr
Office Hour: TBD

- Computer Science Student at Koç University
- Pursuing Artificial Intelligence Tracking Program & Minor Program with Media & Visual Arts
- Interested in music production and video games, playing piano

Teaching Assistants

Yiğit Fatih Çakıllı
ycakilli19@ku.edu.tr
Office Hour: TBD

- Physics Student at Koç University
- Pursuing a Double Major in Computer Engineering
- Interested in running, hiking, cycling, playing the saxophone

Muhammed Can Durmuş
mdurmus19@ku.edu.tr
Office Hour: TBD

- Electrical and Electronical Engineering Student at Koç University (Computer Engineering DM)
- Interested in playing guitar and ice hockey
- Working on web development, design and writing

Prof. Dr. Metin Sezgin

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Director, Intelligent User Interfaces Group

Massachusetts Institute of Technology **MIT** (MS '01)

Massachusetts Institute of Technology **MIT** (PhD '06)

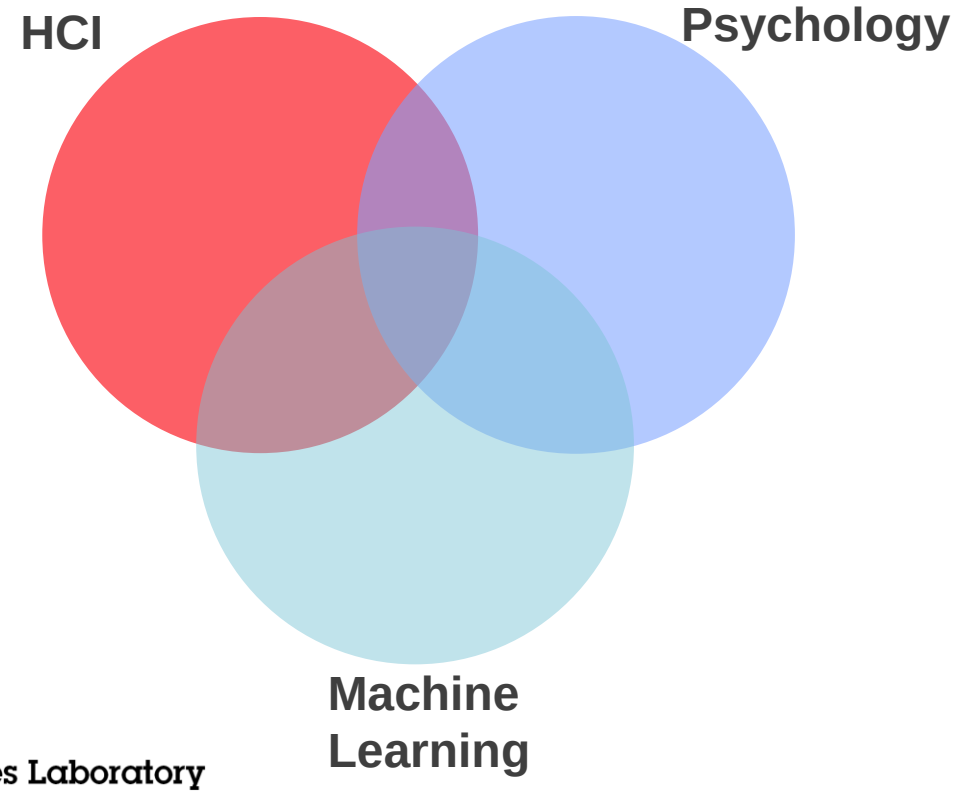
UNIVERSITY OF CAMBRIDGE **postdoc**

HARVARD Yale University **visiting appointments**

KOÇ ÜNİVERSİTESİ **2009 -- …**

- **Areas of expertise**
  - Artificial Intelligence
  - Intelligent User Interfaces
  - Machine learning
  - Multimodal interfaces

Intelligent User Interfaces



Why am I teaching this class?

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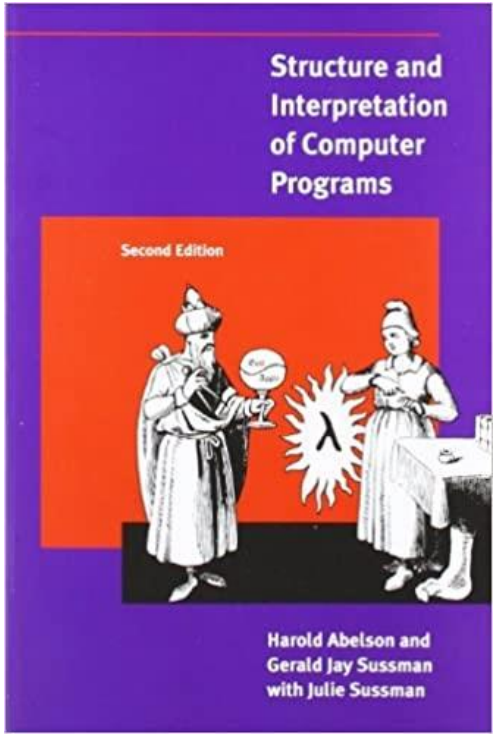
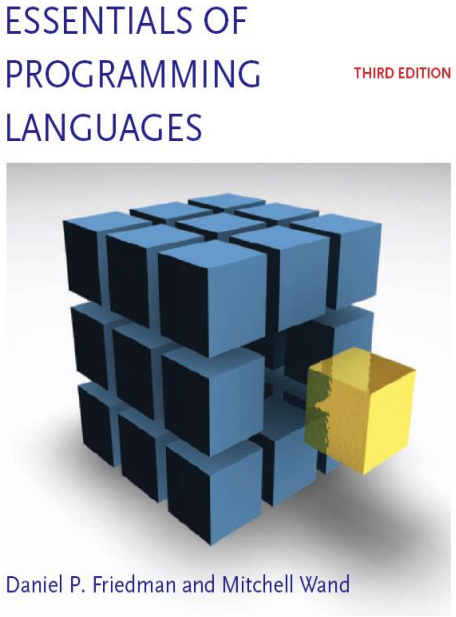
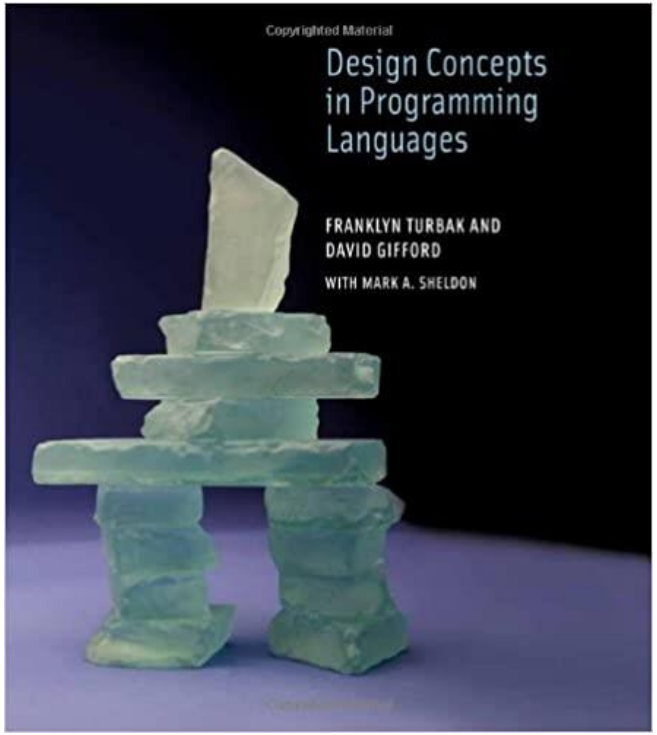






Office Hours

- Instructor
  - By appointment
- TAs
  - Office hours are 1 hour long.
  - Each week a different TA will hold an office hour, at their respective times.
  - These hours will also be declared separately and will be found in the Syllabus document.

Grading

Method	Description	Weight %
Quiz	10 quizzes	10,00
Project	Project	20,00
Midterm Exam	Midterm	25,00
Final Exam	Final	30,00
Participation	Participation	5,00
Laboratory	PS Sessions	10,00
	Total:	100,00

Grading / Quiz

- There can be more than 10 quizzes, however, only the **top 10 highest score** will be counted.
- Quizzes will typically be made at the end of a lecture, or PS session.

Grading / Project

- Students will have a **1-2 week** time for each project.
- Submissions will include the **code**, a **report**, and a **self-assessment** within that report.
- Students can form a **group of 2 or 3**:
  - Those who **could not form a group** will be **randomly assigned one** by the TAs.
  - Students can **change/reform groups** for **each project** if they want to.
  - Students should speak to the TAs in case of a **bad-teammate**.
- **Projects are very important! Midterm** and **Final** questions will be **closely related** to the assets learned during the projects.
- **In case a substantial percentage of the semester goes online, the exam component the course may be reweighted or redesigned at the**

Grading / Participation

- Asking questions during the class, interacting with the class, answering questions etc. count greatly towards participation.
- Problem Sessions (PS) attendance counts towards participation. *More detail on the next slide.*

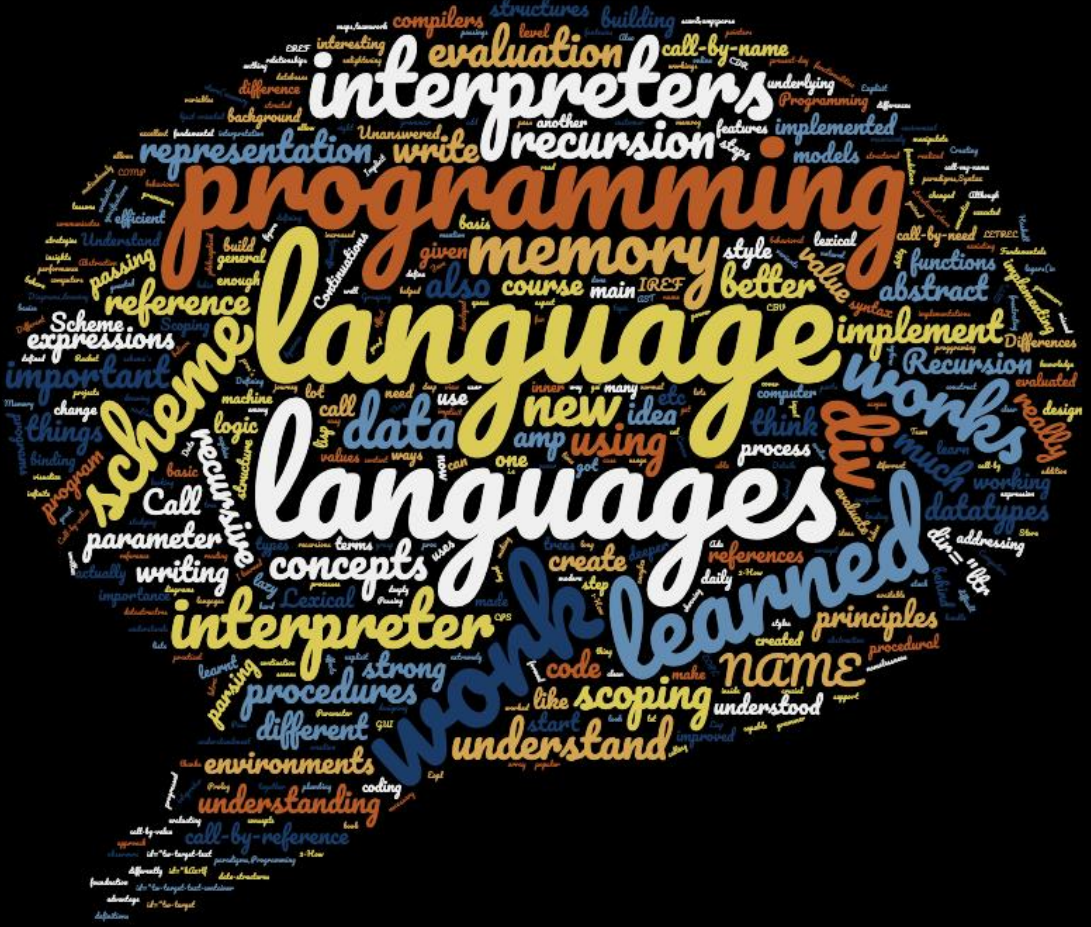
Problem Sessions

- Attendance to the PS’es are **mandatory**. They will contribute towards your participation.
  - You can miss **at most 2 PS’es** only.
- TA’s will conduct the PS’es.
- It will be in a kind of Q&A format, where you can ask questions. We may also give you questions to solve during that PS.

Academic Dishonesty & Recording Disclaimer

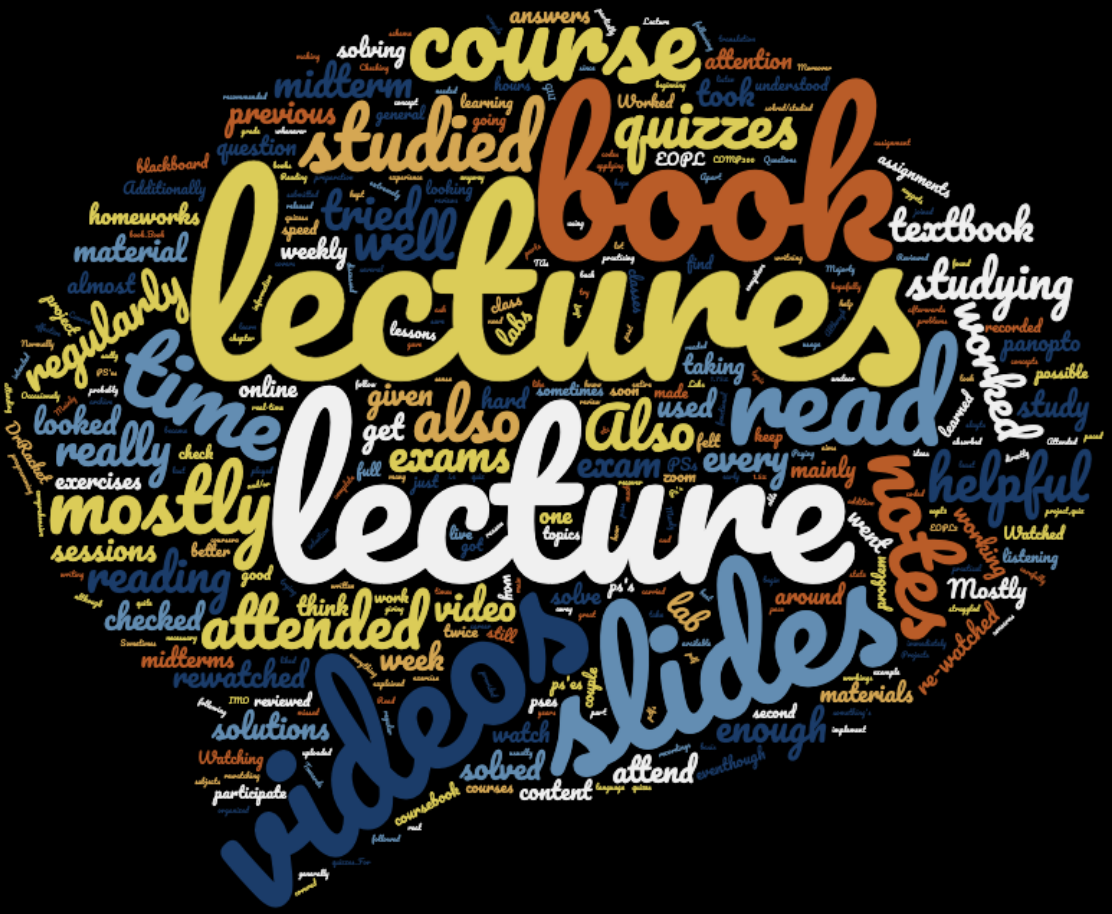
See the University policy, declaration and the recording disclaimer.

Results of the Exit Survey



List three things you have learned in this course?

Give an example of an assignment or an activity that you think you did well to deserve the grade that you expect.

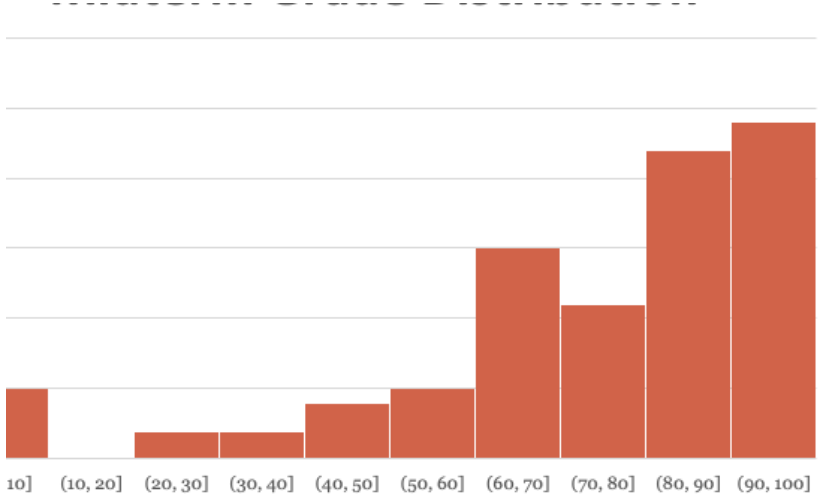


How did you study for this course?

Write 3 things you liked about this course.

A note about your predicted success!

Midterm Statistics



Midterm Statistics

	Average Grades
Group A	69.1
Group B	83.5

Midterm Statistics

	Average Grades
Group A	41.2
Group B	56.4
Group C	71.6
Group D	81.7
Group E	88.8

Midterm Statistics

	Average Grades
Group A	41.2
Group B	53.6
Group C	70.2
Group D	80.2
Group E	87.0
Group F	74
Group G	75.4
Group H	86.5
Group I	90.8

Midterm Statistics

	Average Grades
Group A	69.1
Group B	83.5

Midterm Statistics

Took notes?	Average Grades
No	69.1
Yes	83.5

Midterm Statistics

	Average Grades
Group A	41.2
Group B	56.4
Group C	71.6
Group D	81.7
Group E	88.8

Midterm Statistics

Attendance	Average Grades
%0-%20	41.2
%20-%40	56.4
%40-%60	71.6
%60-%80	81.7
%80-%100	88.8

Midterm Statistics

	Average Grades
Group A	41.2
Group B	53.6
Group C	70.2
Group D	80.2
Group E	87.0
Group F	74
Group G	75.4
Group H	86.5
Group I	90.8

Midterm Statistics

PL-score	Average Grades
0	41.2
1	53.6
2	70.2
3	80.2
4	87.0
5	74
6	75.4
7	86.5
8	90.8

PL-score: 4xL + P

Where **L** = 1 if took lecture notes, 0 otherwise

P = Presence quartile (0 if 0%-20%,
1 if 20%-40%, …)

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Good luck!

How to Use the E-tutor

Visit this presentation (requires KU login):

https://docs.google.com/presentation/d/1lxSwFK06n_dTK4E3Znp5JrWKnx7iHfeQ1ovlC-GktG8/edit?usp=sharing