



# Optimization Theory and Algorithm

## Lecture 1: Introduction

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Center for Intelligent Decision-Making and Machine Learning

School of Management

Xi'an Jiaotong University

# Introduction



## Associate Professor

Center of Intelligent Decision-  
Making and Machine Learning  
Department of Information  
Management and E-business

School of Management

## Address

Room #750, Main Building of  
Management School  
Xi'an Jiaotong University (XJTU)  
China

## Email

xiangyuchang AT xjtu DOT edu DOT  
cn

## Employment Experience

- 2018.12-Present, Visiting Associate Professor (Full time position)  
Department of Industrial & Systems Engineering, University of Washington, Seattle.
- 2016.01-2016.02, Research Associate  
Department of Mathematics, City University of Hong Kong
- 2015.04-2016.04, Visiting Assistant Professor  
Department of Business Statistics and Econometrics, Guanghua School of Management, Peking University

## Education

- 2013-2014, Ph.D., Applied Math, XJTU, China
- 2010-2012, Visiting Ph.D. Student, Statistics, UC Berkeley, U.S.
- 2009-2010, Ph.D. Candidate, Applied Math, XJTU, China
- 2008-2009, M.S., Applied Math, XJTU, China
- 2003-2007, B.S., Applied Math, XJTU, China

## Research Interests

- Statistics & Machine Learning
- Business Data Science

<http://xiangyuchang.github.io/>



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# Optimization Theory and Algorithm

Spring & Fall 2021



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## Optimization Theory and Algorithm / Spring & Fall 2021

### Updates

- New Assignment released: [[HW1: Master LaTeX Template](#)]
- New Lecture is up: Lecture 1 Introduction [[slides](#)] [[notes](#)]
- New course in Spring 2021 is coming soon.

### Course Description

<https://som-course.github.io/opt-spring-2021/>

# Course Description

This course is to present the basic theories and algorithms in optimization fields for undergraduate students at School of Management, Xi'an Jiaotong University. The aim is to give students a thorough understanding of how to construct algorithms for solving optimization problems, and how to develop theories to analyze optimization problems and corresponding algorithms.

Optimization is a special field that is built on three intertwined pillars:

- **Models** give rise to optimization problems.
- **Algorithms** solve optimization problems.
- **Theoretical foundations** support algorithms and models.

**Optimization = Modeling + Algorithm + Theory**

## Instructors



Xiangyu  
Chang



Yao Wang

## Teaching Assistants



Yi Yang



Junbo Hao



Zhikai Yang

# Course Introduction

- 32hr, 9-16 week
- To learn the basic theory and algorithm of optimization
- Why not include the modeling part?
- To learn LaTeX for the scientific writing (HW)
- To practice Python or R for handling optimization problems

# Outline

## Part I: Introduction

- Introduction to Optimization
- Related Mathematical Analysis
- Related Linear Algebra
- ...

## Part II: First-order Method

- Motivation
- Gradient Decent
- Subgradient Decent
- Proximal Gradient Decent
- Convex, Smooth, ...

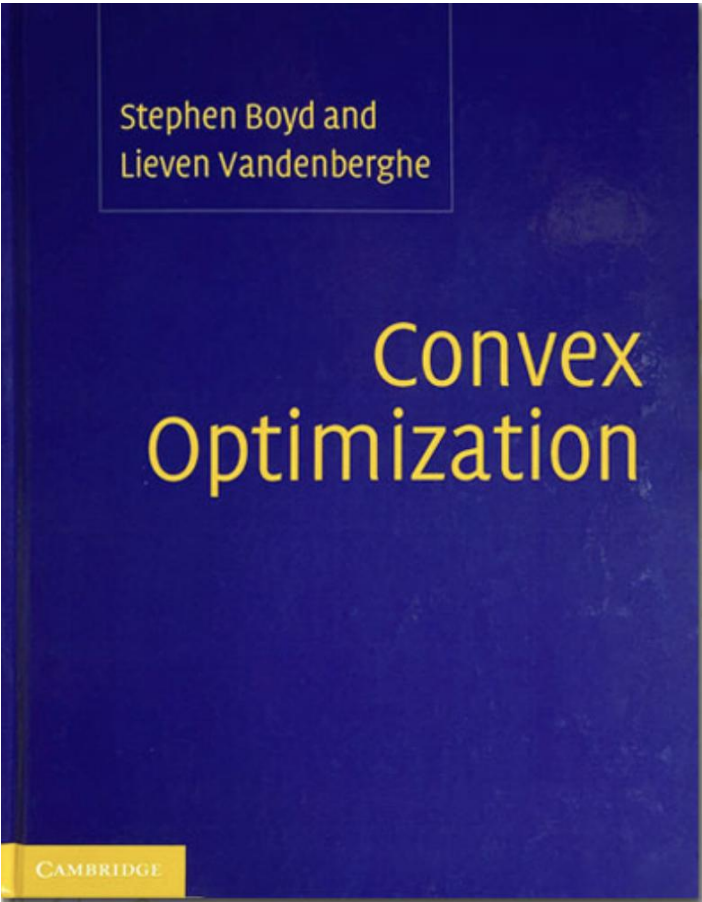
## Part III: Second-order Method

- Motivation
- Newton Method
- BFGS Method
- Quasi-Newton Method
- ...

# Evaluation

- 50%HW + 50%Final Exam = 100%
- Edit your homeworks by LaTeX!

# Text Book







## Materials

### Suggested Text Book

- [Convex Optimization](#) by [Stephen Boyd](#) and [Lieven Vandenberghe](#): a very famous book.
- [最优化：建模、算法与理论](#) by 刘浩洋、户将、李勇锋、文再文编著.

### R

- [R](#)
- [RStudio](#): Suggested IDE
- [R Cheatsheet](#)
- An introduction course of R by Xiangyu Chang: [Lecture 1](#), [Lecture 2](#), [Lecture 3](#), [Lecture 4](#), [Lecture 5](#), [Lecture 6](#)

### Python

- [Python for Beginners](#)
- [Python Cheatsheet](#)
- [Python 数据科学实践](#) by 常象宇, 曾智亿, 李春艳, 程茜著
- [SciPy Tutorial](#)
- [NumPy Quickstart Tutorial](#)

### LaTeX

- [MacTeX](#)



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## Lectures

You can download the lectures here. We will try to upload lectures prior to their corresponding classes.



### Lecture 1 Introduction

tl;dr: introduction lecture

[[slides](#)] [[notes](#)]

#### Suggested Readings:

- [LaTeX Materials](#)
- Section 1.1 and 1.5 of [Liu et al.](#)



课后复习用，每次课结束后公布



课前预习用，每次课之前公布

<https://som-course.github.io/opt-spring-2021/materials/>



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## Assignments

You can download the assignments here. Also check out each assignment page for any additional info.

**HW1: Master LaTeX Template**

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<https://som-course.github.io/opt-spring-2021/assignments/>



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## HW1: Master LaTeX Template

Released on Tuesday 04/27/2021

**Due Date: 2021-04-30 10:00**

**Download** [[problems](#)] [[attachment](#)]

### Late Policy

- Late homework will not be accepted.

This is a sample assignment.

[https://som-course.github.io/opt-spring-2021/assignments/01\\_HW\\_Template](https://som-course.github.io/opt-spring-2021/assignments/01_HW_Template)



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# Optimization Theory and Algorithm

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## Schedule

| EVENT      | DATE                       | DESCRIPTION  | COURSE MATERIAL  |
|------------|----------------------------|--|--|
| Lecture    | 04/27/2021<br>Tuesday      | Lecture 1 Introduction<br><a href="#">[slides]</a> | <b>Suggested Readings:</b> <ul style="list-style-type: none"><li>◦ <a href="#">LaTeX Materials</a></li><li>◦ Section 1.1 and 1.5 of Liu et al.</li></ul> |
| Assignment | 04/27/2021<br>Tuesday      | <b>HW1: Master LaTeX Template released!</b>        | <a href="#">[HW1: Master LaTeX Template]</a>   |
| Due        | 04/30/2021 10:00<br>Friday | Master LaTeX Template for Course Notes.            |  |

<https://som-course.github.io/opt-spring-2021/schedule/>

# LaTeX vs. Word

$$B_{t,\alpha} = \begin{cases} 1 - i\beta \operatorname{sgn}(t) \tan\left(\frac{\pi\alpha}{2}\right) & \text{if } \alpha \neq 1 \\ 1 + i\beta \operatorname{sgn}(t) \frac{2}{\pi} \log |t| & \text{if } \alpha = 1 \end{cases} \quad (2)$$

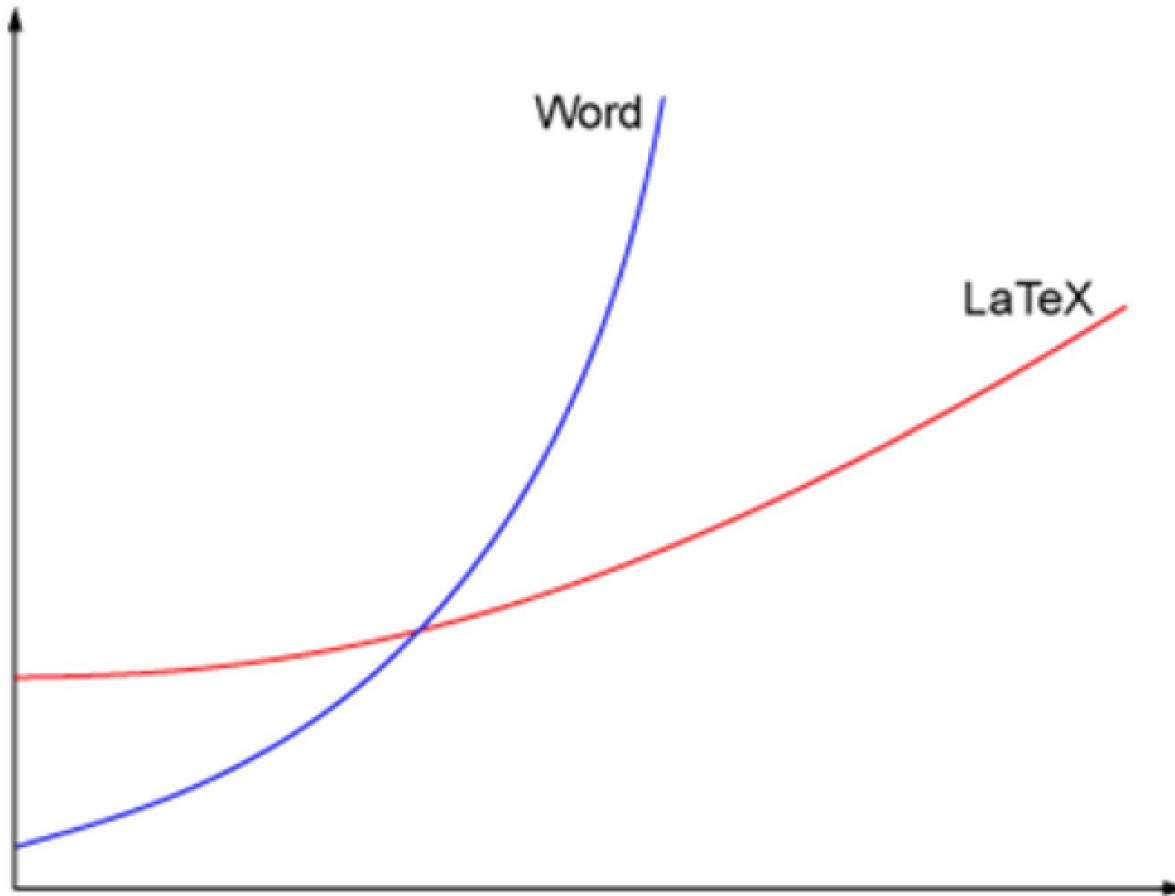
Where  $-\infty < \delta < \boxed{-\infty, \gamma} > 0$ ,  $0 < \alpha \leq 2$ ,  $-1 \leq \beta \leq 1$ .  
 $\alpha$  ( $0 < \alpha \leq 2$ ) is the characteristic exponent and sets the degree of impulsiveness of the distribution. The smaller the value of

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Where  $-\infty < \delta < \boxed{-\infty, \gamma} > 0$ ,  $0 < \alpha \leq 2$ ,  $-1 \leq \beta \leq 1$ .  
 $\alpha$  ( $0 < \alpha \leq 2$ ) is the characteristic exponent and sets the degree of impulsiveness of the distribution. The smaller the value of  $\alpha$ ,

Latex文档格式均匀，黑白和行距均匀，数学格式排版美观

# LaTeX vs. Word



Slides from Prof. Yao Wang

# LaTeX vs. Word

- 如果只是排版一些简单的公文, word就够用了
- 如果需要排版高质量的包含大量数学公式的科技文档, 那就需要用LaTeX
- 用LaTeX时间越长, 就越会发现word的不足, 从而更爱LaTeX
- LaTeX开源, 可免费获得(这一条理由就足够)



# LaTeX: Install

CTEX : HomePage

Homepage Download Search:  Your hostname is 124.237.212.213

## 科技排版系统

### CTEX项目

- CTeX开发小组+
- 套装: 更新记录 / 下载中心
  - v2.9.2.164
- 模版: 国科大学位论文模版+

### 快速链接

- TeX@smth+ / TUG+ / CTAN+ / TUNA+

### TeX发行版

- TeXLive (Unix/Linux/Windows)+
- MacTeX (Mac OSX)+
- MiKTeX (Windows)+

### 帮助文档

- 基本知识
- 在线文档
- CTeX FAQ (常见问题集)

### 新闻公告

- 2018.11.21
  - CTeX论坛因故自即日起无限期关闭。
- 2018.04.01
  - 新版国科大学位论文模版ucasthesis正式发布, 欢迎使用:  
<https://github.com/mohuangrui/ucasthesis>
- 2016.06.15
  - CTeX 套装主要下载新增中国科技大学开源镜像。感谢中国科大开源镜像提供帮助。
- 2016.06.13
  - CTeX 套装主要下载迁移至清华大学TUNA开源镜像, 新版CTeX套装也将通过TUNA开源镜像服务器发布。感谢TUNA提供帮助。
- ...更多新闻公告



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## The MacTeX-2021 Distribution

The current distribution is MacTeX-2021

This distribution requires Mac OS 10.14, Mojave, or higher and runs natively on Intel and Arm processors.

To download, click [MacTeX Download](#).

You can also install TeX Live 2021 using the TeX Live Unix Install Script.

This method supports MacOS 10.6, Snow Leopard, and higher and runs on Intel and Arm processors.

To download, click [Unix Download](#).

To Obtain Older Versions of MacTeX If You Are Running Mac OS 10.3 through 10.13, [click here](#)


To download the smaller BasicTeX, click [Smaller Download](#).

For suggestions on keeping TeX up to date, go to [Update Schedule](#).

The link below leads to other optional download packages:

[MacTeXtras: optional pieces](#)

# LaTeX: Suggested IDE



**TeXstudio**  
LaTeX made comfortable

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- Features
- Download
- Participate
- About

## Welcome to TeXstudio

TeXstudio is an integrated writing environment for creating LaTeX documents. Our goal is to make writing LaTeX as easy and comfortable as possible. Therefore TeXstudio has numerous features like syntax-highlighting, integrated viewer, reference checking, and various assistants. For more details see the [features](#).

TeXstudio is open-source and is available for all major operating systems.

**Download now**

**TeXstudio 3.1.1 (OSX dmg)**  
for macOS 10.14 or higher



## News

- 2021-02-22 A new bugfix release **TeXstudio 3.1.1** is available. Mainly it fixes crashes loading included files. see [changelog](#)
- 2021-02-17 A new bugfix release **TeXstudio 3.1.0** is available. Mainly changing the GUI language has been fixed. Furthermore a global TOC is available besides the structure view. It is work in progress and not (yet) automatically updated. Please give feedback. see [changelog](#)

# LaTeX: How to Learn

## Learn LaTeX in 30 minutes

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In this guide, we hope to give you your first introduction to  $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ . The guide does not require you to have any prior knowledge of  $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ , but by the time you are finished, you will have written your first LaTeX document, and hopefully will have a good knowledge of some of the basic functions provided by  $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ .

## Contents

1. What is LaTeX?
2. Why learn LaTeX?
3. Writing your first piece of LaTeX
4. The preamble of a document
5. Adding a title, author and date
6. Adding comments
7. Bold, italics and underlining
8. Adding images
  - 8.1. Captions, labels and references
9. Creating lists in LaTeX
  - 9.1. Unordered lists
  - 9.2. Ordered lists

# Use Overleaf!!!

[Features & Benefits](#)[Templates](#)[Plans & Pricing](#)[Help](#)[Register](#)

# LaTeX, Evolved

The easy to use, online, collaborative LaTeX editor

The screenshot displays the Overleaf editor interface for a document titled "The Universe". The interface is split into three main sections: a file explorer on the left, a source code editor in the center, and a rendered PDF preview on the right.

**File Explorer (Left):** Shows a project structure with folders "figures" and "sections". Files include "universe.jpg", "main.tex" (selected), and "references.bib".

**Source Code Editor (Center):** Displays the LaTeX source code for "main.tex":

```
1 \documentclass{article}
2 \usepackage[utf8]{inputenc}
3
4 \title{The Universe}
5 \author{}
6 \date{May 2019}
7
8 \usepackage{natbib}
9 \usepackage{graphicx}
10
11 \begin{document}
12
13 \maketitle
14
15 \section{Introduction}
16 There is a theory which states that if ever anyone discovers exactly
17 what the Universe is for and why it is here, it will instantly
18 disappear and be replaced by something even more bizarre and
19 inexplicable.
20 There is another theory which states that this has already happened.
21
22 \begin{figure}[h!]
23 \centering
24 \includegraphics[scale=1.7]{figures/universe.jpg}
25 \caption{The Universe}
26 \label{fig:universe}
27 \end{figure}
28 \end{document}
```

**Rendered PDF Preview (Right):** Shows the output of the LaTeX code. The document has a title page with "The Universe" and "May 2019". It includes an "Introduction" section with a paragraph of text and a figure of a galaxy. The figure is captioned "Figure 1: The Universe". A "Conclusion" section is also visible at the bottom.

# Materials

## Suggested Text Book

- [Convex Optimization](#) by [Stephen Boyd](#) and [Lieven Vandenbergh](#): a very famous book.
- [最优化：建模、算法与理论](#) by [刘浩洋](#)、[卢将](#)、[李勇锋](#)、[文再文](#)编著.

## R

- [R](#)
- [RStudio](#): Suggested IDE
- [R Cheatsheet](#)
- An introduction course of R by Xiangyu Chang: [Lecture 1](#), [Lecture 2](#), [Lecture 3](#), [Lecture 4](#), [Lecture 5](#), [Lecture 6](#)

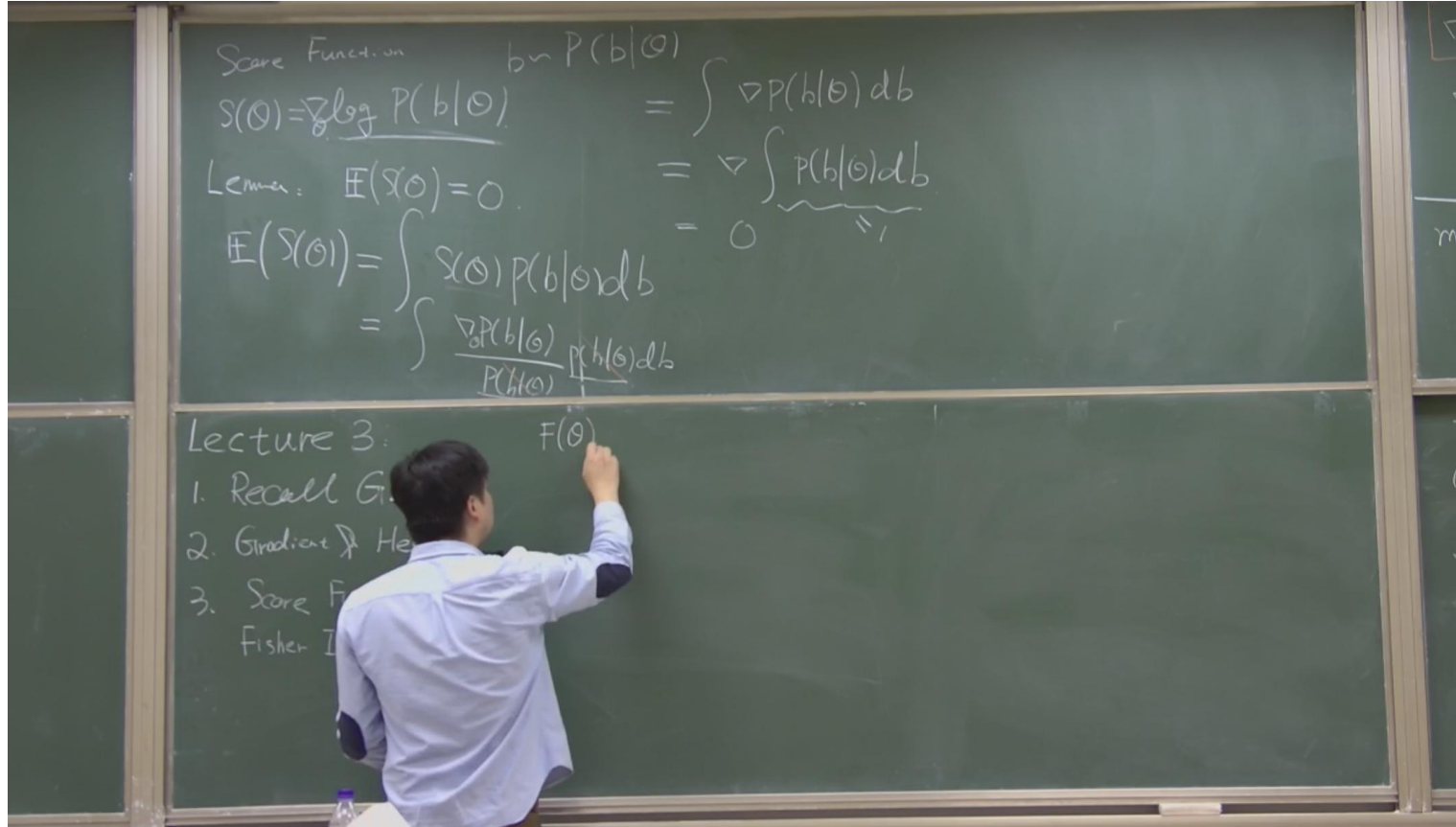
## Python

- [Python for Beginners](#)
- [Python Cheatsheet](#)
- [Python 数据科学实践](#) by [常象宇](#)，[曾智亿](#)，[李春艳](#)，[程茜](#)著
- [SciPy Tutorial](#)
- [NumPy Quickstart Tutorial](#)

## LaTeX

- [MacTeX](#)
- [CTeX](#)
- [Learn LaTeX in 30 minutes](#)
- [Use Overleaf](#)
- [TeXStudio](#): Suggested IDE

# Teaching Style



- Writing on the blackboard in English for main lectures, Speaking in Chinese
- Demostrating codes or visual examples by slides

# Why?



观点 > 人民网评

## 人民网评：一流大学建设要坚持社会主义办学方向

2021-04-22 08:07 人民网-观点频道 作者：岚山



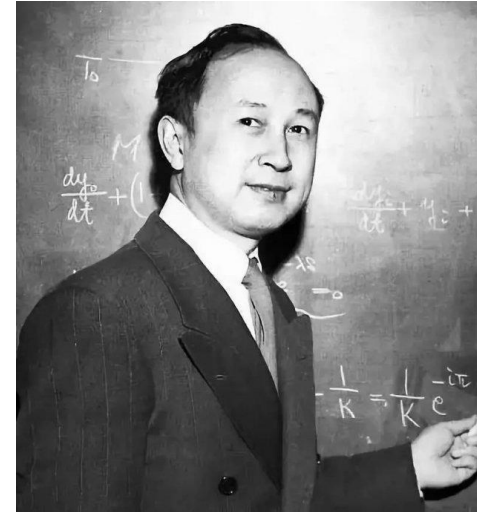
文章指出，教育兴则国家兴，教育强则国家强。在国家发展进程中办好高等教育，办出世界一流大学，首先要在体现中国特色上下功夫。



交通大学上海徐家汇校区老校门（1920年代）

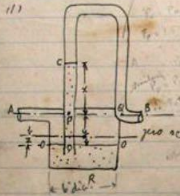


1956年交通大学主体西迁西安庆典

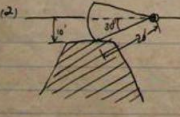


國立交通大學  
年度第 學期  
試 卷  
Hydraulics  
M.E. 年級 五 門 考 題  
試場坐號 3 註冊號數  
教室坐號 20 日期 21.3.1953

姓名 張 華 義  
分數 96

11)  The difference in pressure between P + Q = (1.5 - 1.0) x ft. of water.  
The pressure at P - Pressure at A = -1.5 ft. + 1 ft. = -0.5 ft. of water.  
x + y = scale of pressure diff.  
∴ pressure difference = 0.5 x + 0.5 y = 0.5 (x + y)  
Out (x + y) x 0.5 = z x 6.25  
∴ z = (x + y) x 0.5 / 6.25 = (x + y) x 0.08 / 36 = (x + y) x 1 / 450

∴ pressure difference  
If the pressure difference is 0.100 ft.,  
Then 0.100 = 0.5 (x + y)  
x + y = 0.20 ft.  
∴ scale of pressure diff. = 0.20 x 0.08 / 0.0035 = 0.20 - 0.0035 = 0.1995 ft.

12)  (a) The total horizontal push of the water pressure against the gate = 10' x 5' x 1' x 62.4 # = 3120 #

(b) The volume of water displaced = 1' [ 20' x 20' x 30' / 360 - 1/2 x 20' sin 30° x 20' cos 30° ]



**Questions**





Спасибо

RUSSIAN



Gracias

SPANISH



Merci

FRENCH



CẢM ƠN

VIETNAMESE



谢谢

CHINESE



Thank  
You!

ENGLISH



Ευχαριστώ

GREEK



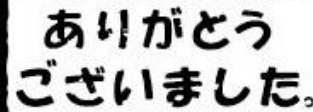
شكراً

ARABIC



고맙습니다

KOREAN



ありがとう  
ございました。

JAPANESE