The need for a paradigm shift in Engineering Education in view of available Computational Power

Kanmani Buddhi
BMS College of Engineering
Bengaluru - INDIA

the learning ideas conference

Conference Proposals

2025 Conference Program

Online-Only Days: Wednesday, May 28th | Thursday, May 29th

Hybrid Days: Wednesday, June 11th | Thursday, June 12th | Friday, June 13th

TRACK 4 (ONLINE) - SESSION 4D

Session Chair: Fariba Moghaddam, Ph.D., University of Applied Sciences Western Switzerland, Sion, Switzerland

9:45 AM - 10:15 AM

The Need for a Paradigm Shift in Engineering Education in View of Available Computation Power

Kanmani Buddhi, Ph.D., BMS College of Engineering, Bengaluru, Karnataka, India

Engineering education can be viewed as the application of fundamental concepts of mathematics, statistics, science and engineering for the benefit of society. The fundamental concepts do not change with time. The distribution of marks secured by students in a class; the height of students in a class; the emoluments earned by the alumni of graduating batch shall always follow the normal distribution with specific mean and standard deviation. The people arriving at a restaurant; the parcels arriving at a post office; the packets arriving at a node in network; always follow the Poisson distribution with interarrival times following the exponential distribution. The frequency components present in a continuous time signal can always be obtained through the Fourier Transform (FT); and this signal can be converted to an equivalent digital signal through the sampling theorem; and its frequency components obtained through the Discrete Fourier Transform (DFT).

https://www.learningideasconf.org/program-02

Acknowledgements

- BMS College of Engineering
- National Board of Accreditation
- IUCEE

Personal Understanding

Engineering Education in India

WASHINGTON ACCORD

WASHINGTON ACCORD

> SIGNATORIES

EXECUTIVE COMMITTEE

HOW TO APPLY

SIGNATORIES

SIGNATORIES HAVE FULL RIGHTS OF PARTICIPATION IN THE ACCORD

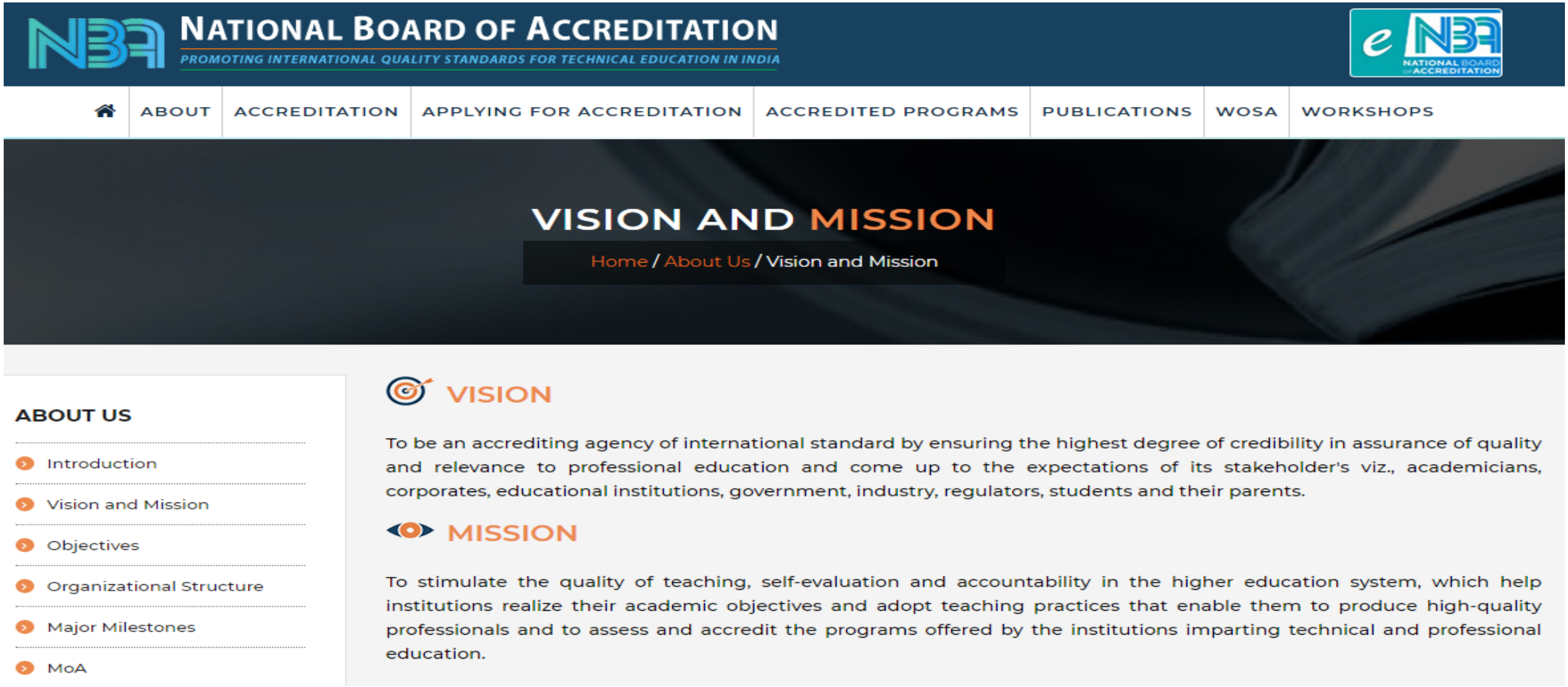
Qualifications accredited or recognized by other signatories are recognised by each signatory as being substantially equivalent to accredited or recognised qualifications within its own jurisdiction.

- → **Korea** - Represented by Accreditation Board for Engineering Education of Korea (ABEEK) (2007)
- → **Russia** - Represented by Association for Engineering Education of Russia (AEER) (2012)
- → **Malaysia** - Represented by Board of Engineers Malaysia (BEM) (2009)
- → **China** - Represented by China Association for Science and Technology (CAST) (2016)
- → **South Africa** - Represented by Engineering Council South Africa (ECSA) (1999)
- → **New Zealand** - Represented by Engineering New Zealand (EngNZ) (1989)
- → **Australia** - Represented by Engineers Australia (EA) (1989)
- → **Canada** - Represented by Engineers Canada (EC) (1989)
- → **Ireland** - Represented by Engineers Ireland (EI) (1989)
- → **Hong Kong China** - Represented by The Hong Kong Institution of Engineers (HKIE) (1995)
- → **Chinese Taipei** - Represented by Institute of Engineering Education Taiwan (IEET) (2007)
- → **Singapore** - Represented by Institution of Engineers Singapore (IES) (2006)
- → **Sri Lanka** - Represented by Institution of Engineers Sri Lanka (IESL) (2014)
- → **Japan** - Represented by JABEE (2005)
- → **India** - Represented by National Board of Accreditation (NBA) (2014)

2014

https://www.ieagreements.org/accords/washington/

The National Board of Accreditation represents India



https://www.nbaind.org/about/vision

The Graduate Attributes (GAs)

defined by

Washington Accord

are aligned with the

The Program Outcomes (POs)

defined by the

National Board of Accreditation

Outcomes Based Education (OBE)

and is addressed

through the

Course Outcomes (COs) of the Curriculum

supported by

Effective Pedagogy *and* ***Relevant Assessments***

The Program Outcomes for Engineering

Program Outcomes (POs)	
PO1	Engineering Knowledge
PO2	Problem Analysis
PO3	Design/Development of Solution
PO4	Conduct Investigations of Complex Problems
PO5	Engineering Tool Usage
PO6	The Engineer and The World
PO7	Professional Ethics
PO8	Individual and Team work
PO9	Communicate Effectively
PO10	Project Management and Finance
PO11	Life-Long Learning

Effective from July 2024

PO5: Engineering Tool Usage

Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve ***complex engineering problems (WK2 and WK6)***

Typical Activities through an Engineering Tool

Programming Language

- ***Equation to Code***
- ***Code to Equation***
- ***Analyze the given Block of Code***
- ***Design, implement, analyze***
- ***Built the Tool Box***

Two Examples

1. *Analog Signal Processing using Python and Multisim*

2. *Digital Signal Processing using Python*

Personal Journey
Learning Lessons
Wish list

The Learning Lessons: Pedagogy

Initial Practice: Pedagogy

- Proprietary Software
- In-built Functions
- Every Experiment was an independent/discrete
- Fixed set of experiments
- Laboratory Manual

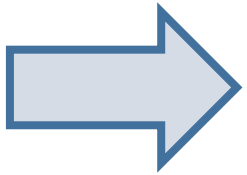
Evolved: Pedagogy

- Open-source Tools
- Avoid In-built Functions
- Student defined Experiments
- Connect between experiments
- Experiential Learning
- Develop the Document
- Tool Box

The Programming Approach

Ability to convert equation to CODE

Mathematical Equation



Develop the CODE

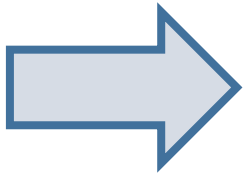
Code, without using inbuilt commands
Use inbuilt command- verification

Aim to use the Tool to understand Signal Processing Concepts
The developed code may not be the most efficient

The Programming Approach: Python

Ability to convert equation to CODE

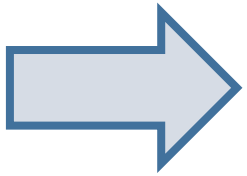
Mathematical Equation



Develop the CODE

Code, without using inbuilt commands
Use inbuilt command- verification

Pen and Paper



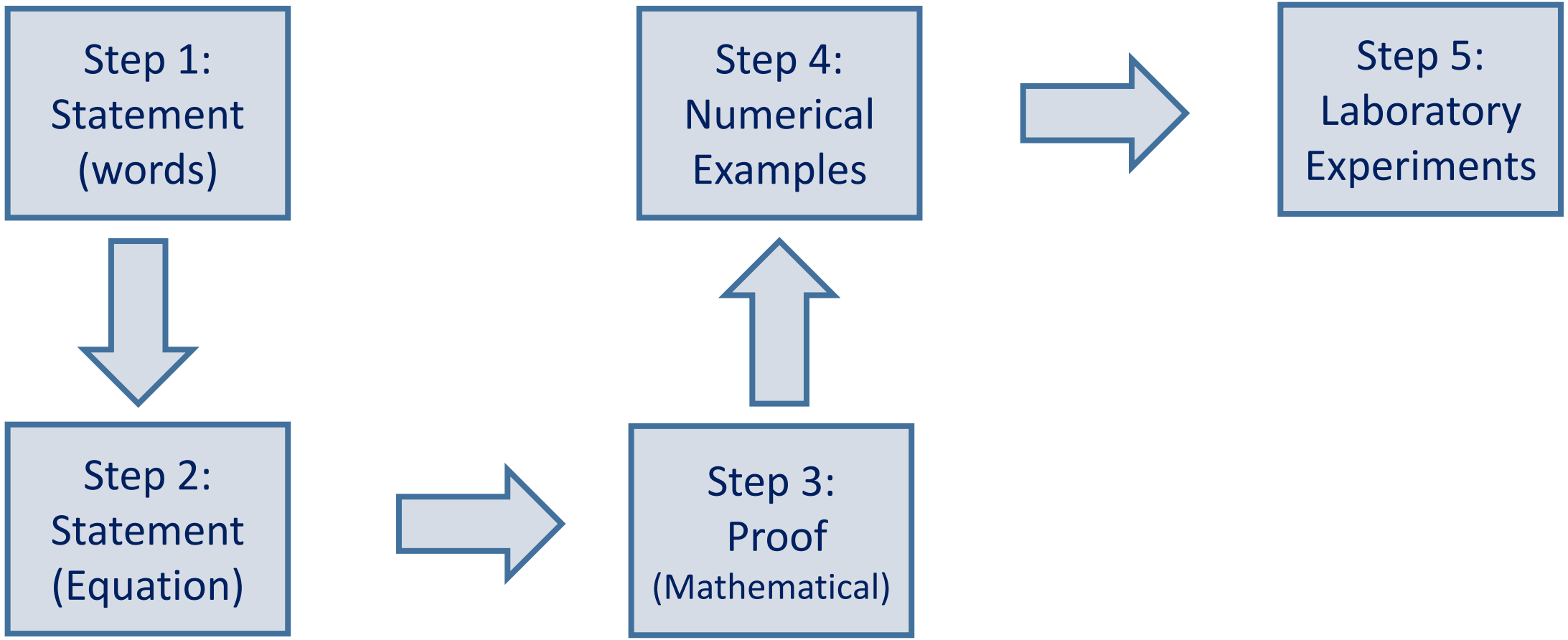
Code

No course in PYTHON

Introduce Commands as required

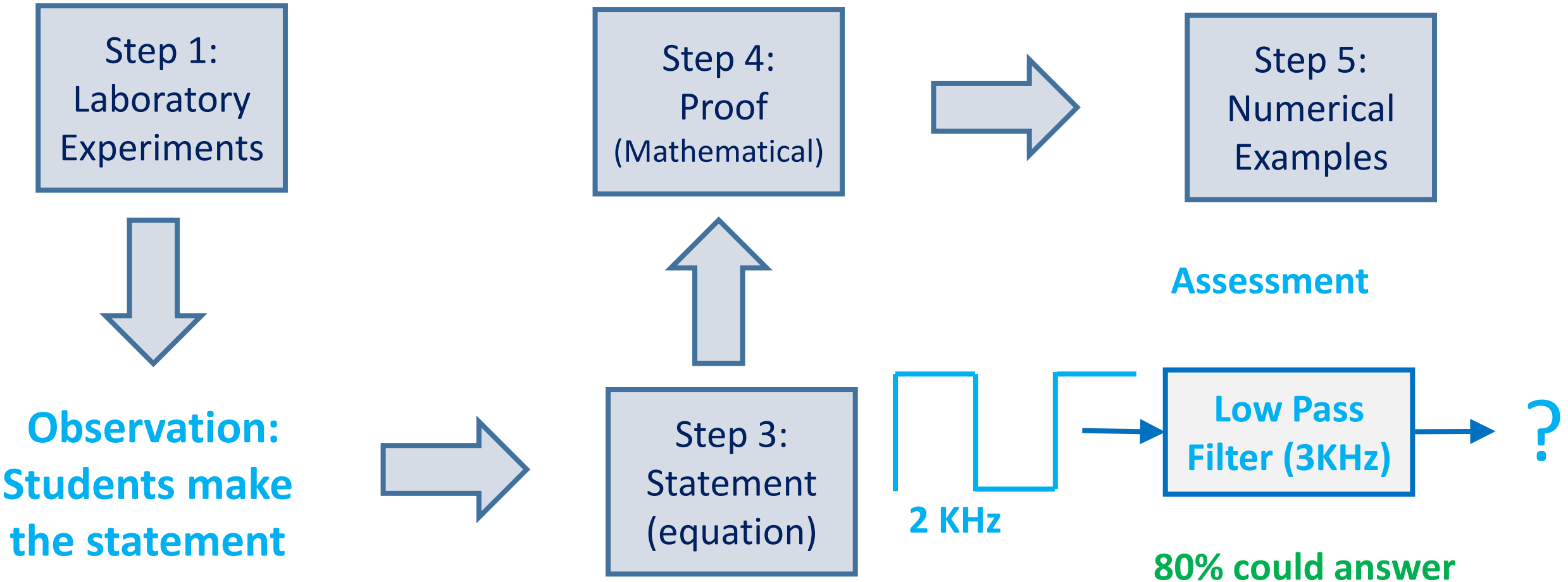
Fourier Series: The usual Pedagogy

Concept: Fourier Series



Changed the Pedagogy: Experiential Learning

Concept: Fourier Series



The Learning Lessons: Internal Assessment

Initial Process

- Marks for every lab session
- Marks for the Record
- One application/ Student designed experiment
- One Internal examination

Evolved Process

- No marks for Regular Lab
- No marks for lab record
- One application/ student designed experiment
- Test 1, Test 2, Quiz

The Learning Lessons: Semester End Assessment

Initial Process

Semester End Assessment

- Give an experiment
- Initial write - up
- Conduction
- Viva

Evolved Process

Semester End Assessment

- Question Paper
- Solve using the Tool Box
- Carry the Lab Record
- Viva

Open Book
Carry the Lab Record
Access to the Tool Box Developed

Analog Signal Processing Lab (Python and Multisim)
Core Course – III Semester

Analog Signal Processing Lab

- Core Course in the III Semester
- Introduces two Engineering Tools: **Python** and **Multisim**
- Assume no prior knowledge in both Python and Multisim
- Laboratory sessions are designed to support the concepts of the Course on ‘Analog Signal Processing’
- Experiential learning is adopted for few concepts
- The Laboratory examination is ‘Open Book’, Access to all codes developed
- NO in-built functions used

Course	Course Outcome	PO
Analog Signal Processing Laboratory using Python and Multisim	Develop the code for the given mathematical equation/ signal processing concept *(WK2)*	PO1 PO5
	Analyze the given code/ analog system and arrive at relevant conclusions *(WK2, WK3)*	PO2 PO5
	Design, implement and Analyze the anolog Butterworth filters to meet given specifications *(WK2, WK3)*	PO2 PO3 PO5
	Build the Analog Signal Processing Tool Box *(WK2, WK3, WK9)*	PO5 PO10 PO11

Analog Signal Processing Lab

Week 1: Python as Calculator

Typical Examples:

- Addition/ Multiplication of numbers
- Exponential/Logarithm of constants
- Trigonometric function (sine/cosine)
- Complex number representation
- If-else statement
- for loop

Week 2: Plot of signals

Typical Examples:

- Plot of Signals
- Plot of functions
- Subplots
- Plot Signal and its Square

Functions Developed:

- my_Plot_Signal
- my_Unit_Step
- my_Sync
- my_Rect_Pulse
- my_Power
- my_Energy

Week 3: Statistical Averages

Typical Examples:

- Statistical averages
- Sequence with Uniform/ Gaussian distribution
- Density/ Cumulative functions
- Signals with added noise

Functions Developed:

- my_Mean
- my_Variance
- my_STD
- my_Integration
- My_Differentiation

The Tool Box: Analog Signal Processing

- Week 01 PYTHON As a Calculator
- Week 02 PYTHON Plot of Signals
- Week 03 PYTHON Functions
- Week 04 PYTHON Statistical Averages
- Week 05 MULTISIM Passive Circuits
- Week 06 PYTHON Pole Zero Plot
- Week 07 PYTHON Summation of sinusoids
- Week 08 PYTHON Fourier Transform
- Week 09 MULTISIM RC Circuit.docx
- Week 09 PYTHON RC Circuit
- Week 10 PYTHON Filter Analysis
- Week 11 MULTISIM Implementation of Butterworth Filters
- Week 12 PYTHON Design of Butterworth Filters

NO in-built functions used

Digital Signal Processing Lab using Python
Core Course – IV Semester

Course	Course Outcome	PO
Digital Signal Processing *(using Python)*	Develop the code for the given mathematical equation/ signal processing concept *(WK2)*	PO1, PO5
	Analyze the given code/ digital system and arrive at relevant conclusions *(WK2, WK3)*	PO2, PO5
	Develop the code for the design of digital filters to meet given specifications *(WK2, WK3)*	PO3, PO5
	Design and implement an application of signal processing concepts for the classroom *(WK2, WK3)*	PO3, PO5, PO6
	Build the Digital Signal Processing Tool Box*(WK2, WK3, WK9)*	PO5, PO10, PO11

The Tool Box: Digital Signal Processing

- Week 01 Introduction
- Week 02 Elementary Digital Signals
- Week 03 Analysis of FIR systems
- Week 04 Analysis of IIR Systems
- Week 05 DFT and its Properties - Part I
- Week 06 DFT and its Properties - Part II
- Week 07 Design of FIR Filters Window Functions
- Week 08 Design of FIR Filters Frequency Sampling Method
- week 09 Design of IIR Filters using Impulse Invariant Method
- week 10 Design of IIR Filters using Bilinear Transform
- week 11 Aliasing Interpolation and Decimation Wavelet Transforms
- week 12 Wavelet Transforms and its applications

NO in-built functions used

Assessment of Laboratory Component

The Conventional Written Examination	In the Laboratory: Can also be solved using Paper and Pen	In the Laboratory: Cannot be solved using Paper and Pen
Closed Book	***Open Book***	***Open Book***
20% weightage	**80% weightage**	

Open Book

Carry the Lab Record

Access to the Tool Box Developed

The Course: Signals and Systems Analog

Assessment of Laboratory Component

The Conventional Written Examination

Closed Book

Give the output for the following Python Code; All questions carry equal Marks

```
A = np.pi
print(np.round(A,3))
```

```
A = np.exp(-1)
    print(np.round(A,2))
```

```
A = np.cos(np.pi/2)
print(np.round(A,3))
```

```
A = np.tan(np.pi/4)
print(np.round(A,3))
```

```
A = np.exp(1j * np.pi/2)
print( np.round(A,3))
```

```
A = np.exp(1j*3*np.pi/4)
print( np.round(A,3))
```

```
t = np.linspace(0,20,5)
print(t)
```

```
for n in range(5):
    val = n*n
    print(val)
```

```
for n in range(5):
    val = n*n
print(val)
```

```
Marks = 90
if Marks < 40:
    print('Fail')
else:
    print('Pass')
```

Sample Question Paper

Attributes Developed through an Engineering Tool

Design assessments to measure the ability to:

- ***Recall syntax***
- ***Apply***
- ***Analyze***
- ***Design/ Develop***
- ***Investigate***
- ***Team work***

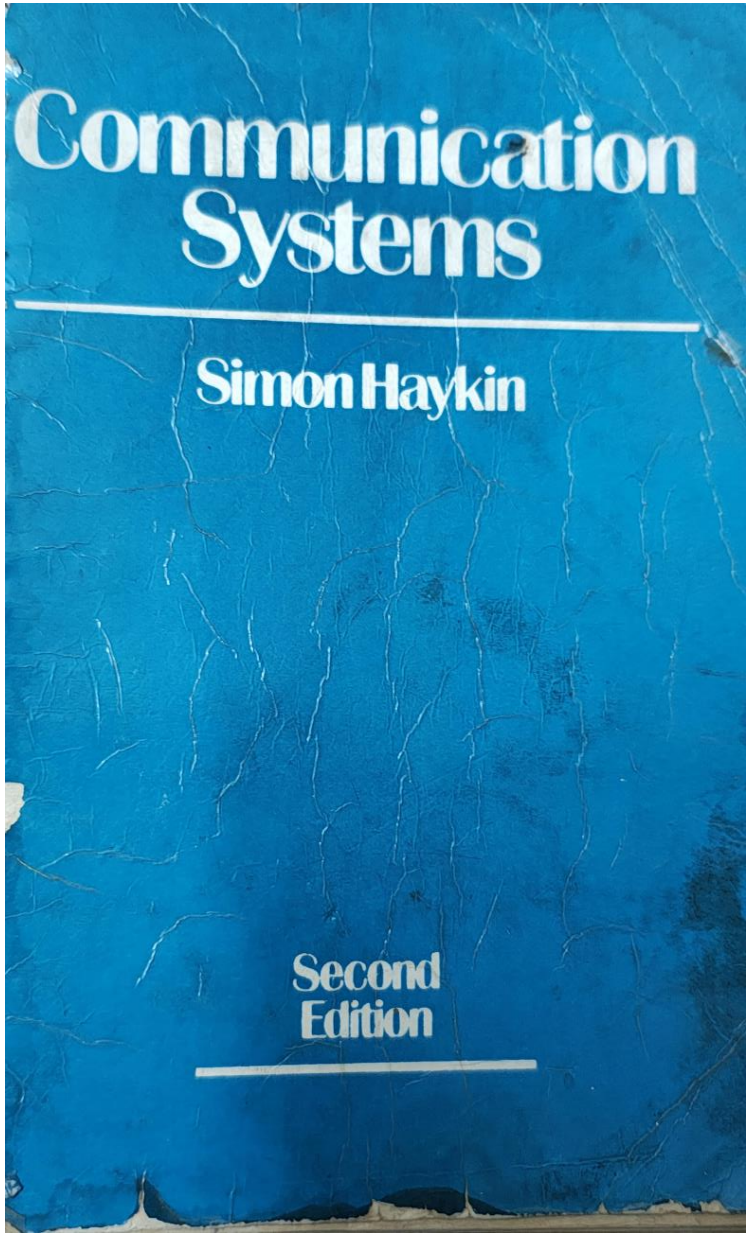
Double Edged Sword

We the Faculty

When we graduated

Text Books

Tables at the 'Back of the Book'



Probability Distribution functions

Appendix 1
CONTINUOUS PROBABILITY DISTRIBUTIONS

In this appendix we list the probability density function, distribution function, mean, and variance of some continuous random variables that are frequently encountered. In each case, the parameter a is a positive constant. Also, the probability density function in each case is illustrated.

1 UNIFORM DISTRIBUTION

$$f_X(x)=\begin{cases}\frac{1}{2a}, & -a\leq x\leq a\\ 0, & \text{elsewhere}\end{cases}$$

$$F_X(x)=\begin{cases}0, & x<-a\\ \frac{1}{2a}(x+a), & -a\leq x\leq a\\ 1, & x>a\end{cases}$$

Mean $=0$

Variance $=\frac{a^2}{3}$

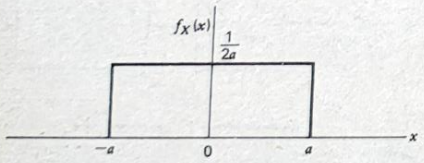


Figure A1.1 Uniform distribution.

2 GAUSSIAN DISTRIBUTION

$$f_X(x)=\frac{1}{\sqrt{2\pi}a}\exp\left(-\frac{x^2}{2a^2}\right), \quad -\infty<x<\infty$$

$$F_X(x)=\frac{1}{2}\left[1+\text{erf}\left(\frac{x}{\sqrt{2}a}\right)\right], \quad -\infty<x<\infty$$

Mean $=0$

Variance $=a^2$

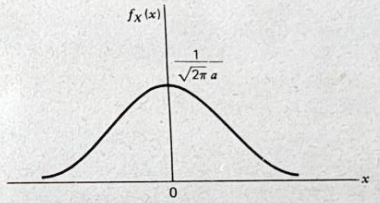


Figure A1.2 Gaussian distribution.

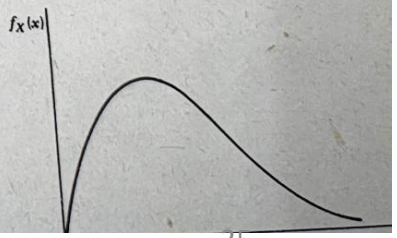
3 RAYLEIGH DISTRIBUTION

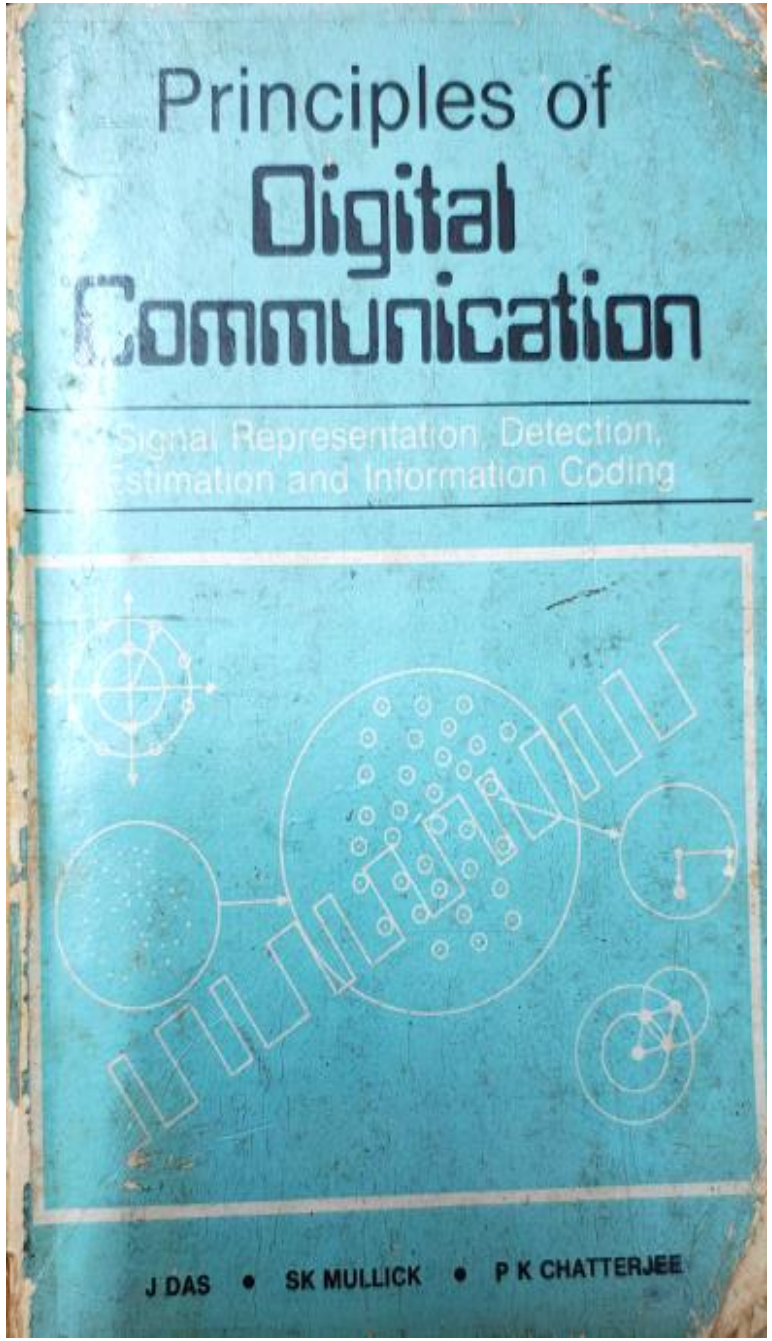
$$f_X(x)=\begin{cases}\frac{x}{a^2}\exp\left(-\frac{x^2}{2a^2}\right), & x\geq 0\\ 0, & x<0\end{cases}$$

$$F_X(x)=\begin{cases}0, & x<0\\ 1-\exp\left(-\frac{x^2}{2a^2}\right), & x\geq 0\end{cases}$$

Mean $=\sqrt{\frac{a^2\pi}{2}}$

Variance $=\left(2-\frac{\pi}{2}\right)a^2$





The Complementary Error functions

Appendix D

TABLE OF COMPLEMENTARY ERROR FUNCTION

Define:

$$\operatorname{erf}(x) \triangleq \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}} e^{-z^2/2}\, dz$$

and

$$\operatorname{erfc}(x) = [1 - \operatorname{erf}(x)] = \int_{x}^{\infty} \frac{1}{\sqrt{2\pi}} e^{-z^2/2}\, dz \qquad (1)$$

An alternative definition of error function, used by some authors, *is*:

$$\operatorname{erf}_*(x) \triangleq \frac{2}{\sqrt{\pi}} \int_{0}^{x} e^{-z^2}\, dz.$$

and

$$\operatorname{erfc}_*(x) = [1 - \operatorname{erf}_*(x)] = 2 \operatorname{erfc}(\sqrt{2}x) \qquad (2)$$

Eqs. (1) and (2) relate the two definitions. Further, erfc (x) may be approximated as:

$$\operatorname{erfc}(x) \simeq \frac{1}{\sqrt{2\pi}x} \exp\left(-\frac{x^2}{2}\right) \quad \text{for } x \geqslant 4$$

and

$$\operatorname{erfc}(x) \simeq \tfrac{1}{2}\left[1 - \sqrt{\frac{2}{\pi}}\, x\right] \quad \text{for } x \text{ small } (x \leqslant 0.1).$$

Table below gives the values of erfc (x) for $.01 \leqslant x \leqslant 5.0$.

x	erfc(x)	x	erfc$(x$	x	erfc(x)
.00	.5000	.15	.4404	.30	.3821
.01	.4960	.16	.4364	.31	.3783
.02	.4920	.17	.4325	.32	.3745
.03	.4880	.18	.4286	.33	.3707

The available computational power

Simple Codes to be developed for the Tables at the 'Back of the Book'

The Engineering Tool

When we graduated

Text Books

Treasure

The available Computational Power

When the student Graduates:

- List the concepts of Mathematics
- List the concepts of Science
- List the concepts of ALL Courses of the Curriculum
  (concepts, that can be implemented using the Tool)

- Develop Code for the concepts using Open Source Tool
- Without using in-built functions
- Use them only to verify the result

IEEE SSCI

Conferences > 2002 IEEE International Confe...

The continuous-time signals and systems concept inventory

Publisher: IEEE Cite This PDF

Kathleen E. Wage ; John R. Buck ; Thad B. Welch ; Cameron H. G. Wright **All Authors**

2	148
Paper Citations	Full Text Views

https://ieeexplore.ieee.org/document/5745562

Opportunity to meet
Prof Kathllen E Wage and Porf. John R Buck
IEEE DSP SPE conference 2011, Arizona

The Concepts Inventory

The IEEE Signals and Systems Concepts Inventory (SSCI)

Continuous Time

Discrete Time

K. E. Wage, J. R. Buck, C. H. G. Wright and T. B. Welch, 'The signals and systems concept inventory', in *IEEE Transactions on Education*, vol. 48, no. 3, pp. 448-461, DOI: 10.1109/TE.2005.849746; August 2005

The Concepts Inventory

The IEEE Signals and Systems Concepts Inventory (SSCI)

Continuous Time

Discrete Time

Our Curriculum:

Analog Signal Processing

Digital Signal Processing

B Kanmani , "Introducing signals and systems concepts through analog signal processing first", IEEE Signal processing society: 14th DSP Workshop & 6th SPE Workshop, Enchantment Resort, Sedona, Arizona, 4th -7th January, 2011
DOI: 10.1109/DSP-SPE.2011.5739191, Publication Year: 2011 , Page(s): 84 – 89

The Available Computational Power

The IEEE Signals and Systems Concepts Inventory (SSCI)

Continuous Time

Discrete Time

Explore Course:
SSCI – CT
SSCI – DT
Certification

Acknowledgements

The Learning Ideas Conference Team

- *Abstract of the Talk*
- *Submission of Paper – optional*
- *Review Process*
- *The presentation, uploaded on YouTube*

TLIC 2023

Chapter 8:

Buddhi, K. (2023).

A Pedagogy for Engineering Concepts Focusing on Experiential Learning.

In: Guralnick, D., Auer, M.E., Poce, A. (eds) Creative Approaches to Technology-Enhanced Learning for the Workplace and Higher Education. TLIC 2023. Lecture Notes in Networks and Systems, vol 767. Springer, Cham.

https://doi.org/10.1007/978-3-031-41637-8_8

YouTube Video: https://youtu.be/X-wxfeVhYtY?si=YLJeVaGxcY0XkEga

TLIC 2023

A Pedagogy for Engineering Concepts Focusing on ...

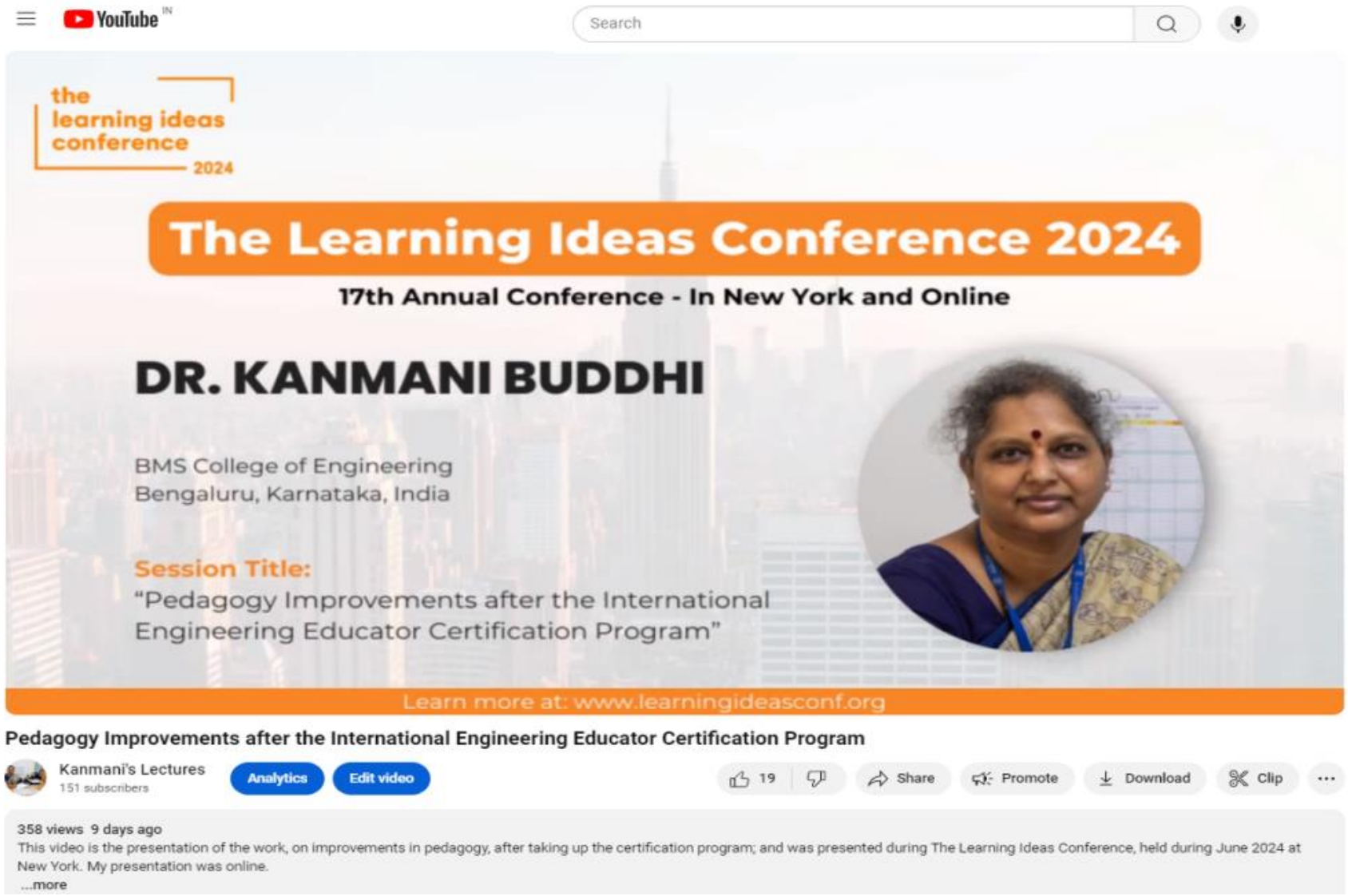
YouTube · Kanmani's Lectures · 15 Jul 2023

Time Lines

0:00	Introduction
4:00	**The Usual Pedagogy**
10:20	Memorable Moments
11:30	About IUCEE
14:28	IEEE Signals and Systems Concepts Inventory
19:27	**Outcome Based Education (OBE)**
23:24	**Online Teaching** *(experience during Pandemic)*
25:00	Negative Feedback on PPT
30:40	**Experiential Learning** *(Fourier Series ; Sampling Theorem; Central Limit Theorem)*
38:42	Student Survey
40:43	Conclusions
44:00	Acknowledgements
47:44	Concluding Remarks

YouTube Video: https://youtu.be/X-wxfeVhYtY?si=YLJeVaGxcY0XkEga

TLIC 2024



Chapter 5:
Buddhi, K. (2024).
Pedagogy Improvements After the International Engineering Educator Certification Program.
In: Guralnick, D., Auer, M.E., Poce, A. (eds) Creative Approaches to Technology-Enhanced Learning for the Workplace and Higher Education. TLIC 2024. Lecture Notes in Networks and Systems, vol 1150. Springer, Cham. https://doi.org/10.1007/978-3-031-72430-5_5

YouTube Video: https://youtu.be/r4l28YYX9gw?si=CA6cIZJ4WBn1sxjO

TLIC 2024

Time Lines

The video is a bit long (**45 Minutes**)
The timelines of the video are:
Initial 10 seconds - Blank

0:10	Introduction by Session Chair
1:25	Start of the presentation
3:15	About the IIEECP course
9:00	Engineering Education in India
11:00	About BMS College of Engineering
15:00	Design of the Signal Processing Course Content
20:00	Improvements in Pedagogy
	(i) Defining COs (**21:18**)
	(ii) Pre-Test (**23:25**
	(iii) Office Hour (**26:00**)
	(iv) Activity Based Delivery (**26:44**)
	(v) The Laboratory Component (**33:00**)
	(vi) Self-Evaluation by Students (**38:00**)
	(vii) Contribution to POs (**39:00**)
40:00	Reflections
42:00	Interoperability of Python and Matlab
45:00	Summary of the session

Pedagogy Improvements after the International Engineering ...
YouTube · Kanmani's Lectures · 12 Aug 2024

YouTube Video: https://youtu.be/r4l28YYX9gw?si=CA6cIZJ4WBn1sxjO

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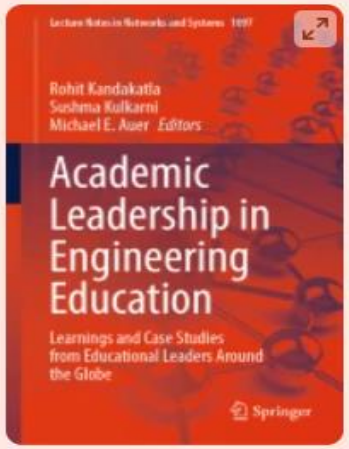
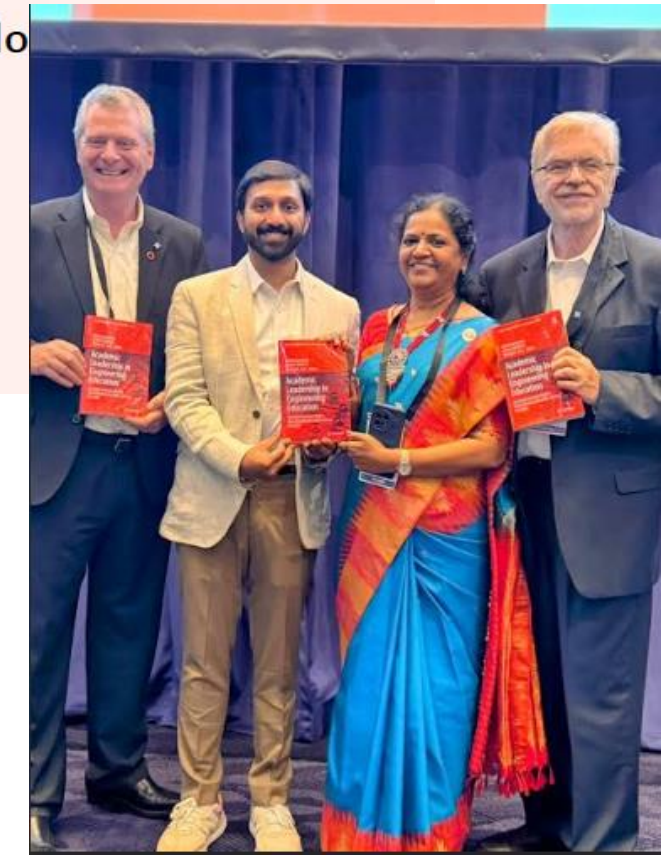


Academic Leadership in Engineering Education

Learnings and Case Studies from Educational Leaders Around the Glo

Book | Dec 2024



The Book was formally released during WEEF 2024, Sydney, Australia, December 2, 2024

Acknowledgements to the Editors
For sharing this memorable moment

Chapter 3:
Establishing and maintaining operational systems and processes that meet international quality standards

S.A. Rajala, President-Elect, Board of Directors and Chair, Global Council, **ABET, USA**

D. Iacona, Director, International Engagement and Governance, **ABET, USA**

M.I. Ruiz Cantasani, Liaison and Training Partners Director, School of Engineering and Sciences, Tecnologico de Monterrey, **Mexico**

V. Lara-Prieto, National Head of Higher Education, School of Engineering and Sciences, Tecnologico de Monterrey, **Mexico**

B. Kanmani, Department of Electronics and Telecommunication Engineering, BMS College of Engineering, **India**

Rajala, S.A., Iacona, D., Ruiz-Cantisani, M.I., Lara-Prieto, V., Kanmani, B. (2025). Establishing and Maintaining Operational Systems and Processes that Meet International Quality Standards. In: Kandakatla, R., Kulkarni, S., Auer, M.E. (eds) Academic Leadership in Engineering Education. Lecture Notes in Networks and Systems, vol 1097. Springer, Cham. https://doi.org/10.1007/978-3-031-68282-7_3

Chapter 6:
Transformation to Outcome Based Education

Prakash Tewari, KLE Technological University, **India**

B. Kanmani, Department of Electronics and Telecommunication Engineering, BMS College of Engineering, **India**

David Knight, Department of Engineering Education, Virginia Tech, **USA**

Marlene Kanga, Former President World Federation of Engineering Organizations **Australia**

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- In two weeks online course, the team introduced us to both Data Science and Python

Participant of this Course

'Digital Signal Processing Concepts using Python', B Kanmani; ISTE-WPLP Learning Material series with specialization in, 'Electronics and Communication', from the Indian Society for Technical Education, (An AICTE Project), published by Khanna Book Publishing Co. (P) Ltd., New Delhi, First Edition 2023; Reprint 2024; ISBN 978-93-5538-268-9; (*Also available as e-Book*)

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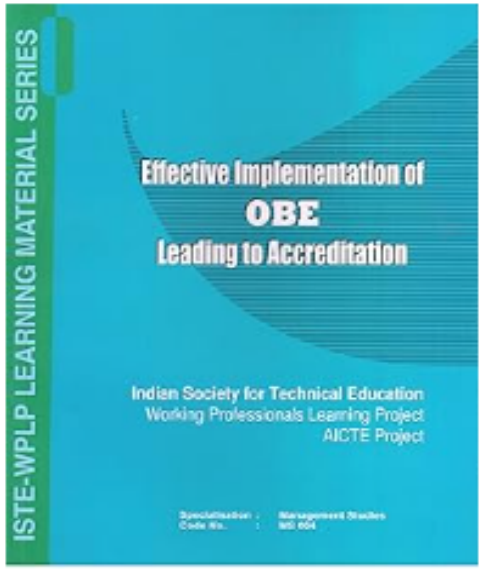

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AI Overview

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Kanmani Buddhi is a professor in the Department of Electronics and Telecommunication Engineering at BMS College of Engineering, Bangalore. She has expertise in digital signal processing and has authored a book titled "Digital Signal Processing Concepts Using Python". Khanna Publishing House published this book.

Key aspects of Kanmani Buddhi's work in Digital Signal Processing:

Published Book:

She is the author of "Digital Signal Processing Concepts Using Python," which is a resource for learning the subject.

Teaching and Research:

She teaches a course on Signal Processing and Communication at BMS College of Engineering. She has also contributed to research in areas like Diffuse Optical Tomography and PAPR reduction.

Publications and Presentations:

She has published papers in journals and presented at conferences related to signal processing and engineering education.

Online Lectures:

She has uploaded lectures on Digital Signal Processing and Outcome-Based Education on her YouTube channel, Kanmani's Lectures.

Professional Affiliations:

She is a Senior Member of the IEEE, a Fellow of the IETE, and a Life Member of ISTE.

AI responses may include mistakes.

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Thank you!