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Definitions

- **Computer Security** - generic name for the collection of tools designed to protect data and to thwart hackers
- **Network Security** - measures to protect data during their transmission
- **Internet Security** - measures to protect data during their transmission over a collection of interconnected networks

Cryptography

- **Cryptography** – *Secret writing*

  from the Greek for "secret writing" is the mathematical "scrambling" of data so that only someone with the necessary ***key*** can "unscramble" it.

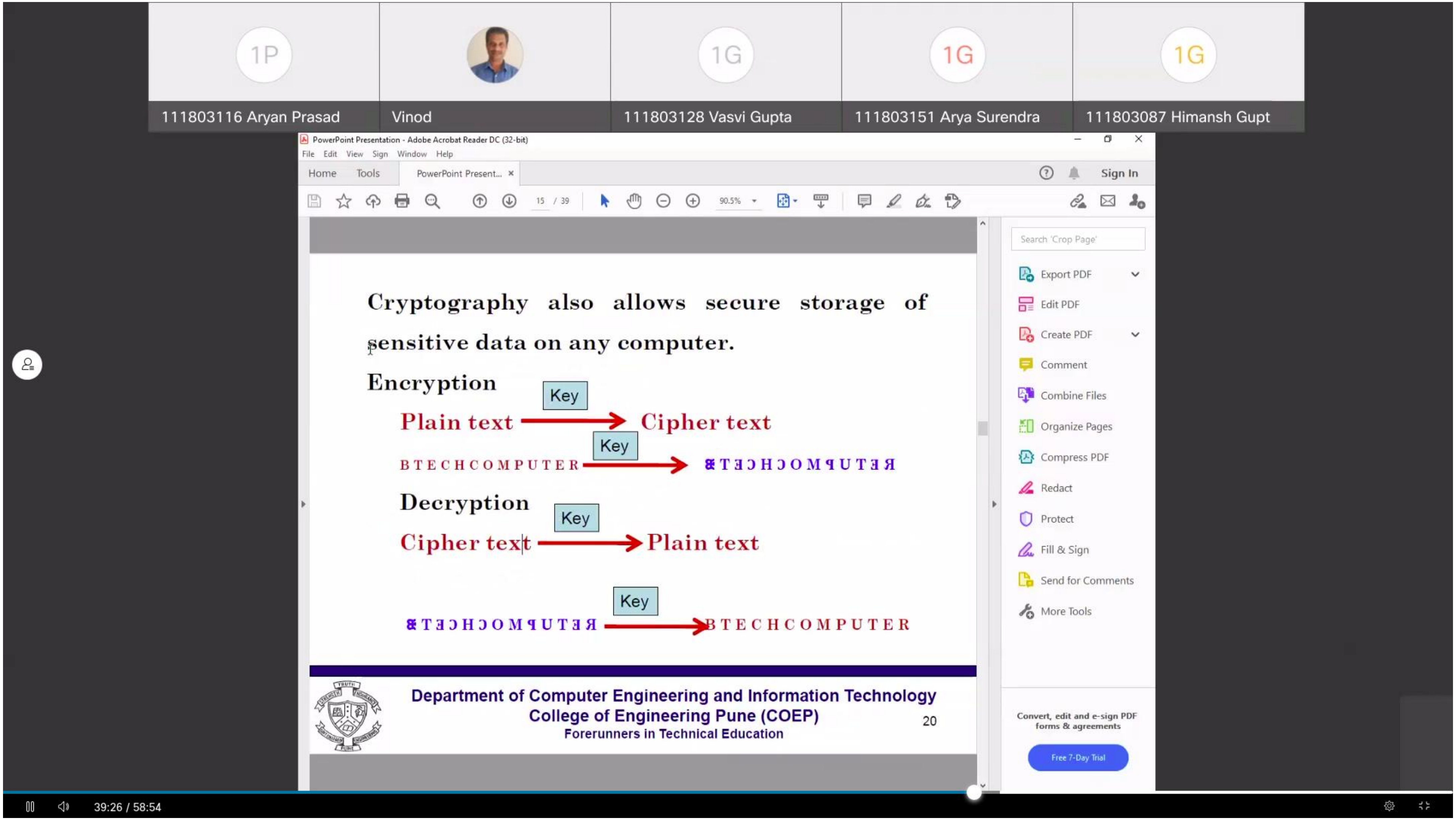
- Cryptography allows secure transmission of private information over insecure channels

Plaintext – A message in its natural format readable by an attacker (Original message/data)

Ciphertext – Message altered to be unreadable by anyone except the intended recipients (Encoded message/data)

Key – Sequence that controls the operation and behavior of the cryptographic algorithm (Password)

Keyspace – Total number of possible values of keys in a crypto algorithm (ex. Suppose the key is binary and the key size is 3 then keyspace is 2^3.)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Cryptography also allows secure storage of sensitive data on any computer.
Encryption
Key
Plain text → Cipher text
Key
BTECHCOMPUTER → ꓭTƎƆHƆOMꟼUTƎЯ
Decryption
Key
Cipher text → Plain text
Key
ꓭTƎƆHƆOMꟼUTƎЯ → BTECHCOMPUTER
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20
39:26 / 58:54

1A	1M	1B	1S	1M
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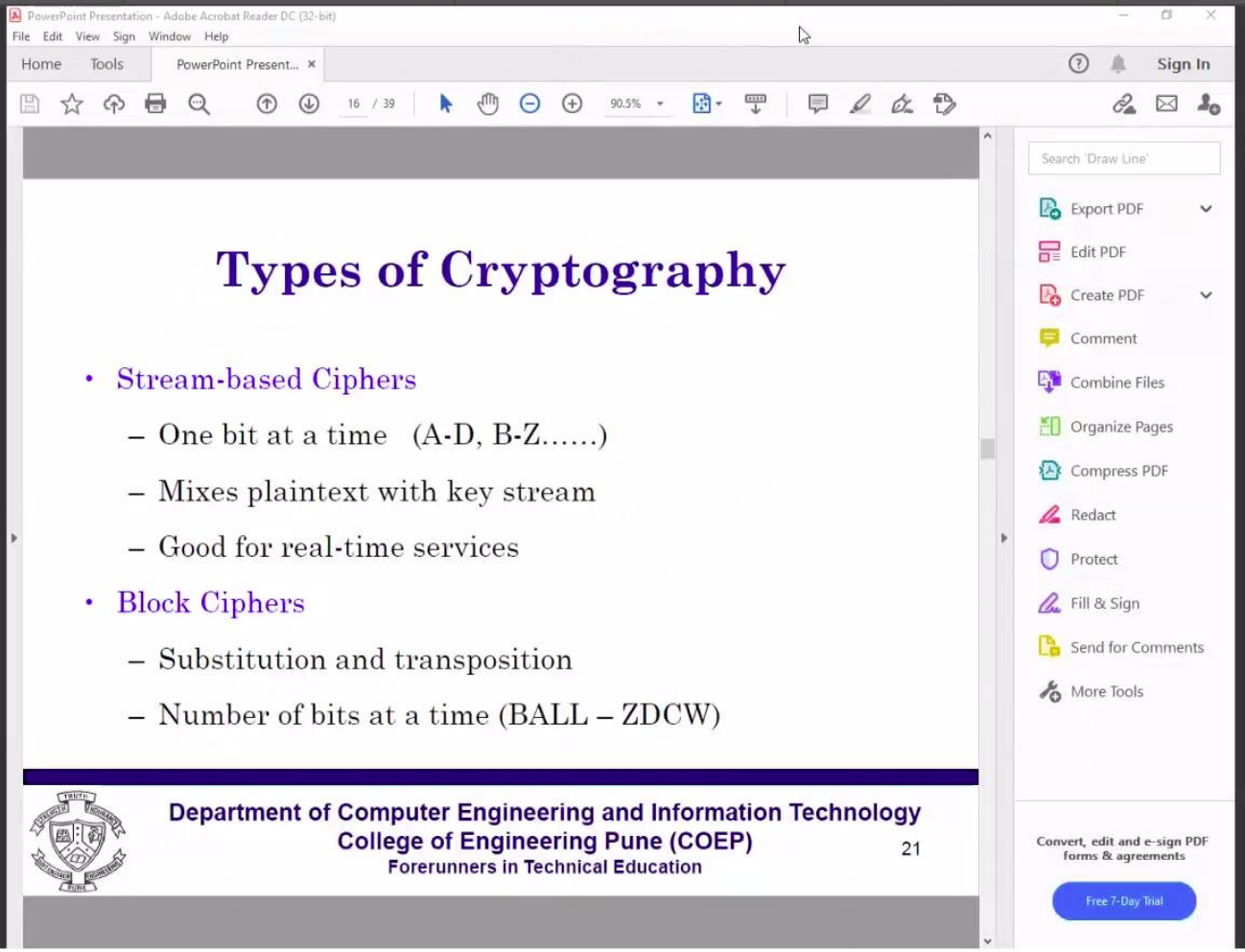

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Types of Cryptography

- Stream-based Ciphers
  - One bit at a time (A-D, B-Z……)
  - Mixes plaintext with key stream
  - Good for real-time services
- Block Ciphers
  - Substitution and transposition
  - Number of bits at a time (BALL – ZDCW)

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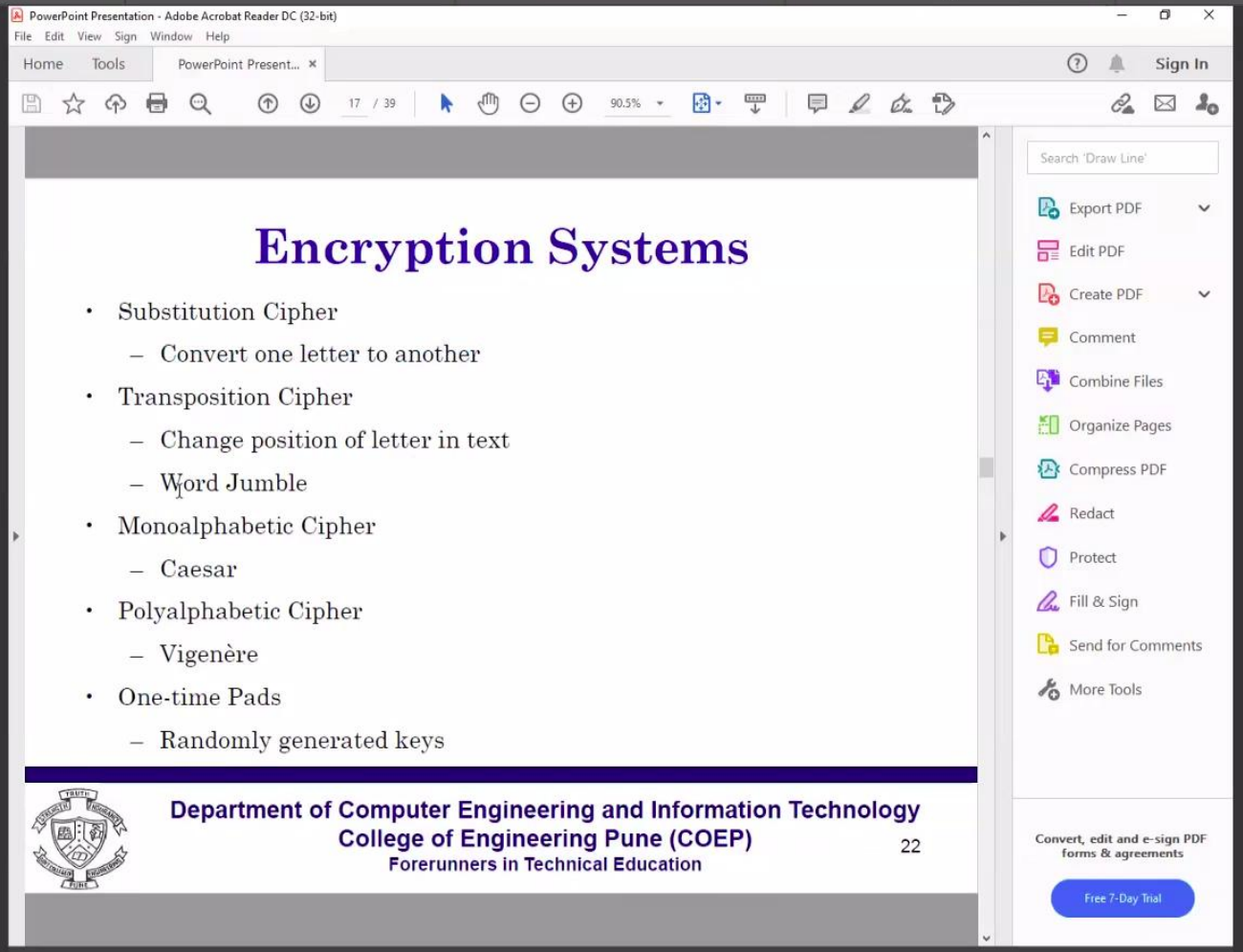

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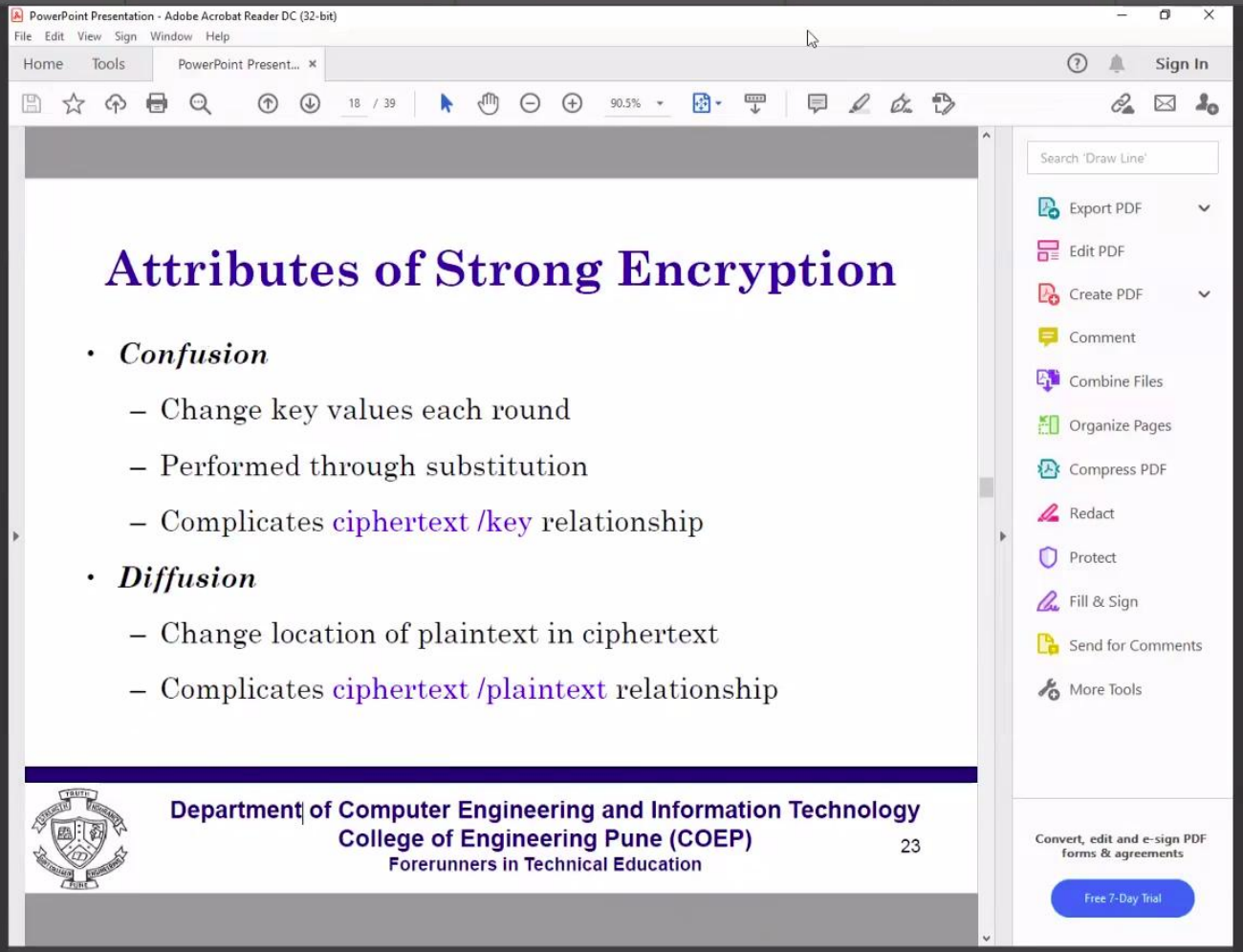

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Hashing Algorithms

- **MD5**
  - Computes 128-bit hash value
  - Widely used for file integrity checking
- **SHA-1**
  - Computes 160-bit hash value
  - NIST approved message digest algorithm
- **RIPEMD-160**
  - Developed in Europe published in 1996
  - Patent-free

Three Aspects of Information Security

- Security attack
- Security mechanism
- Security service

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Security Service

- is something that enhances the security of the data processing systems and the information transfers of an organization
- intended to counter security attacks
- make use of one or more security mechanisms to provide the service
- eg. have signatures, dates; need protection from disclosure, tampering, or destruction; be notarized or witnessed; be recorded or licensed

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Security Mechanism

- a mechanism that is designed to detect, prevent, or recover from a security attack
- no single mechanism that will support all functions required
- however one particular element underlies many of the security mechanisms in use: **cryptographic techniques**

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Security Attack

- any action that compromises the security of information
- information security is about how to prevent attacks, or failing that, to detect attacks on information-based systems

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Security Services

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Authentication

- assurance that the communicating entity is the one claimed
  - **Peer Entity Authentication**: Used in association with a logical connection to provide confidence in the identity of the entities connected.
  - **Data Origin Authentication**: In a connectionless transfer, provides assurance that the source of received data is as claimed.

Data Confidentiality

- protection of data from unauthorized disclosure
  - **Connection Confidentiality**: The protection of all user data on a connection.
  - **Connectionless Confidentiality**: The protection of all user data in a single data block
  - **Selective-Field Confidentiality**: The confidentiality of selected fields within the user data on a connection or in a single data block.
  - **Traffic Flow Confidentiality**: The protection of the information that might be derived from observation of traffic flows.

Data Integrity

- assurance that data received is as sent by an authorized entity
- i.e., contain no modification, insertion, deletion, or replay
  - Connection Integrity with Recovery: Provides for the integrity of all user data on a connection and detects any modification, insertion, deletion, or replay of any data within an entire data sequence, with recovery attempted.
  - Connection Integrity without Recovery: As above, but provides only detection without recovery.

- Selective-Field Connection Integrity: Provides for the integrity of selected fields within the user data of a data block transferred over a connection and takes the form of determination of whether the selected fields have been modified, inserted, deleted, or replayed.
- Connectionless Integrity: Provides for the integrity of a single connectionless data block and may take the form of detection of data modification. Additionally, a limited form of replay detection may be provided.

1D	1J		1S	1D
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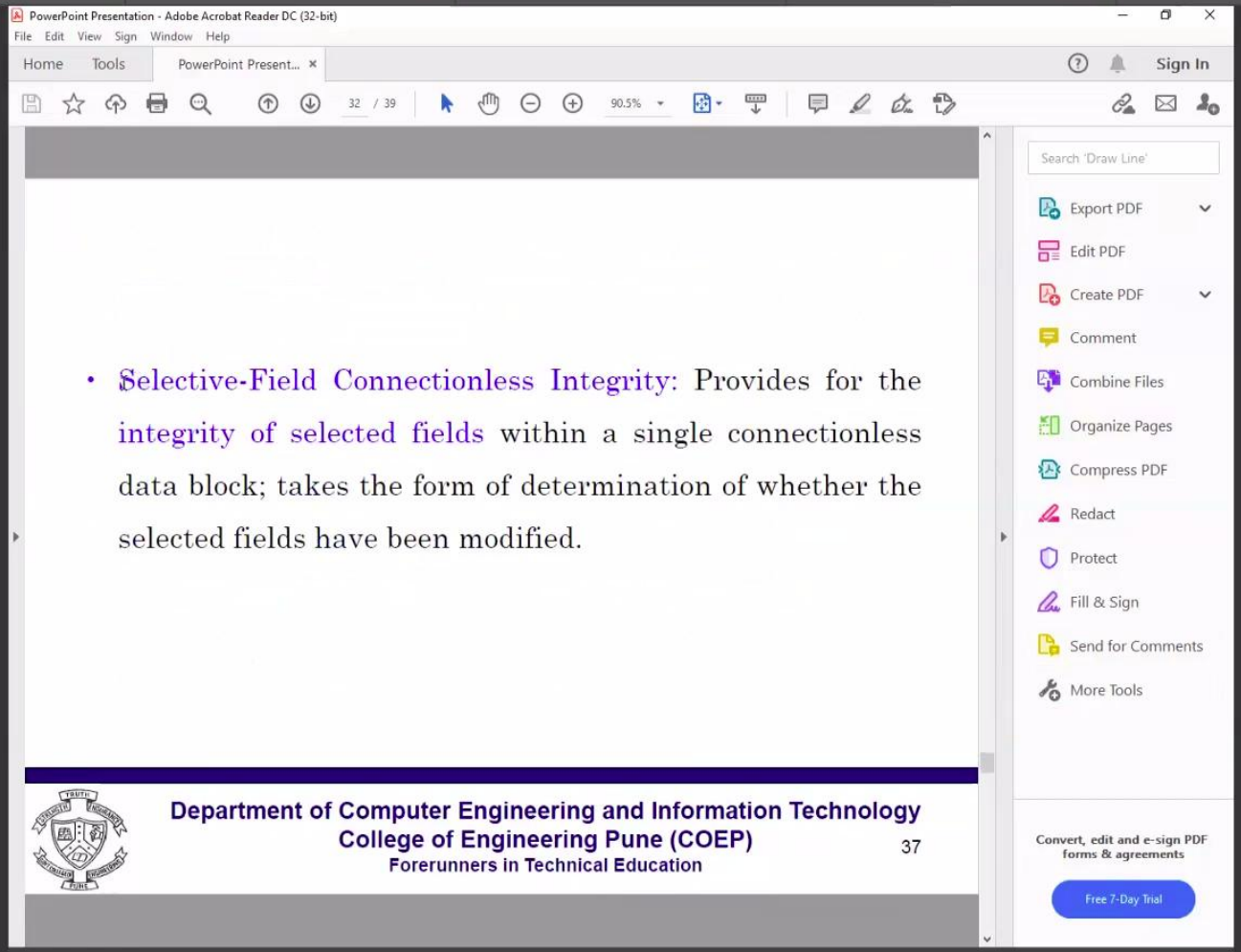

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Non-Repudiation

- protection against denial by one of the parties in a communication
  - Non-repudiation, Origin: Proof that the message was sent by the specified party
  - Non-repudiation, Destination: Proof that the message was received by the specified party

Non-Repudiation

- protection against denial by one of the parties in a communication
  - Non-repudiation, Origin: Proof that the message was sent by the specified party.
  - Non-repudiation, Destination: Proof that the message was received by the specified party

Security Mechanisms (X.800)

- Specific security mechanisms:
  - encipherment, digital signatures, access controls, data integrity, authentication exchange, traffic padding, routing control
- Pervasive security mechanisms:
  - trusted functionality, security labels, event detection, security audit trails, security recovery

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1 Classical Encryption Techniques
2 Symmetric Encryption
3 Asymmetric Encryption
4 Basic Terminology
5 Symmetric Cipher Model
6 Types of Cryptanalytic Attacks
7 Brute Force Search
8 Classical Substitution Ciphers

Classical Encryption Techniques

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Symmetric Encryption

- conventional / private-key / single-key
- sender and recipient share a common key
- DES, Triple DES, AES, IDEA, Blowfish, RC4, RC5, RC6

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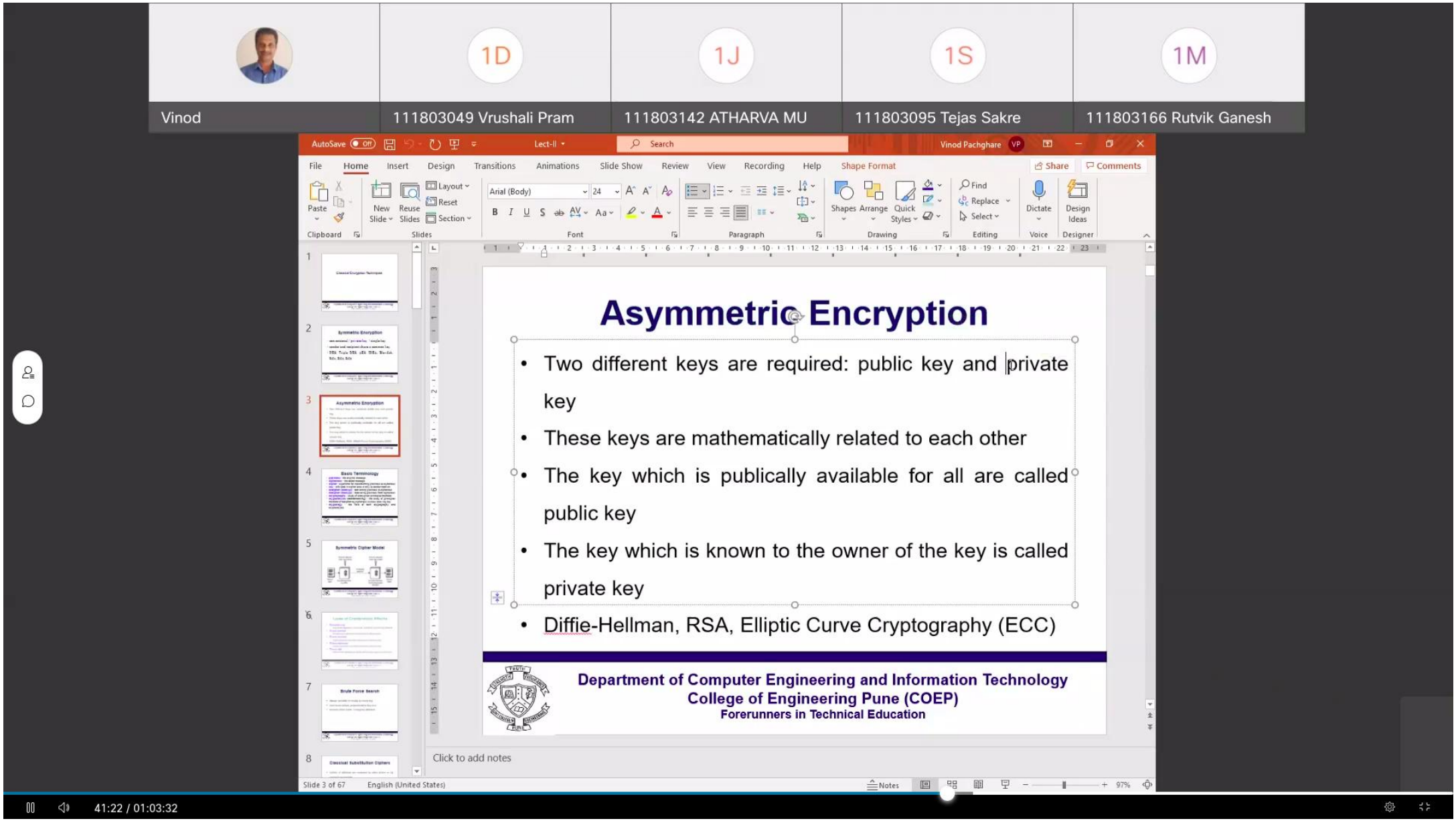
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Asymmetric Encryption
Two different keys are required: public key and private key
These keys are mathematically related to each other
The key which is publically available for all are called public key
The key which is known to the owner of the key is called private key
Diffie-Hellman, RSA, Elliptic Curve Cryptography (ECC)
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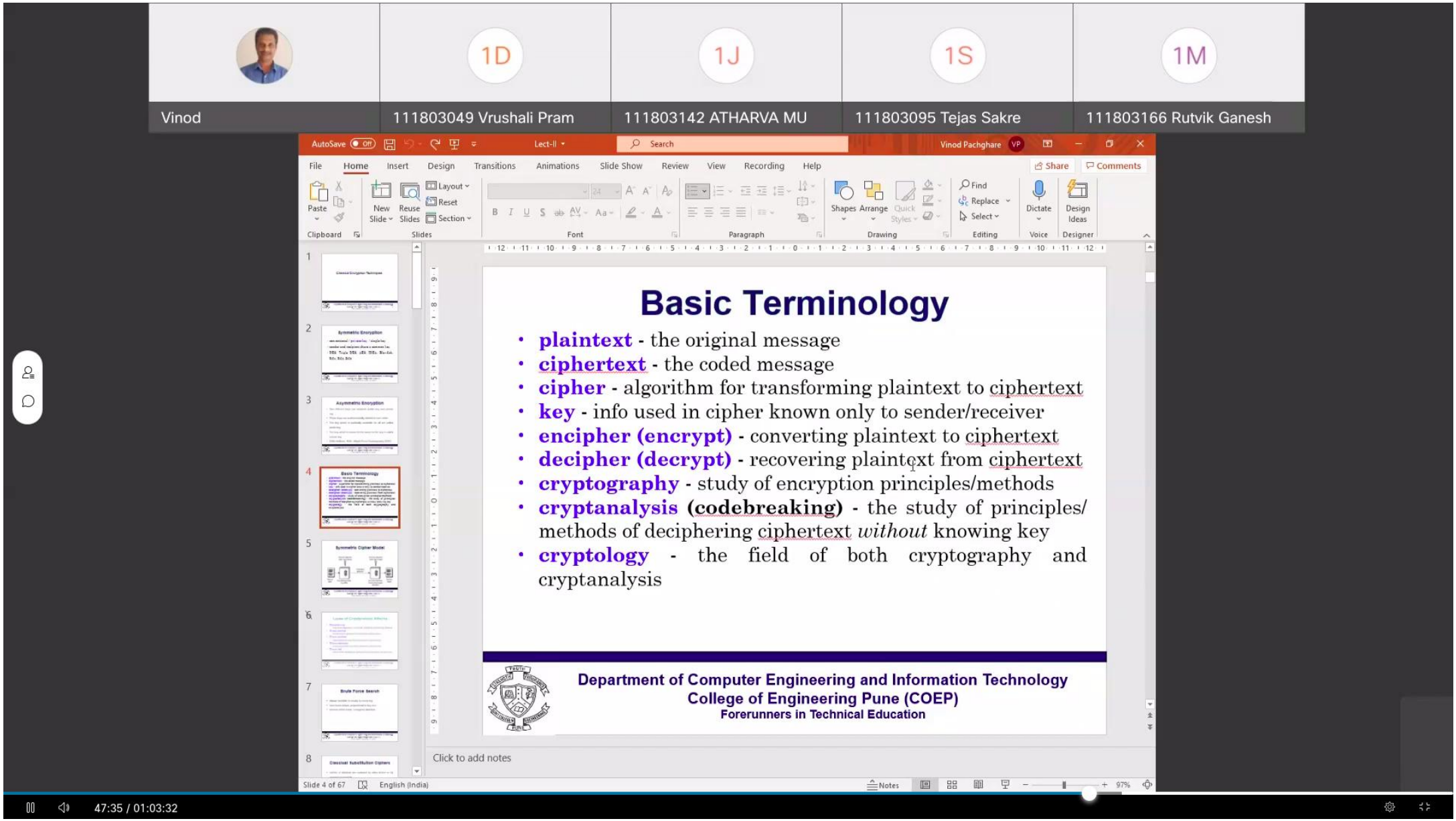
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111803095 Tejas Sakre
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Basic Terminology
plaintext - the original message
ciphertext - the coded message
cipher - algorithm for transforming plaintext to ciphertext
key - info used in cipher known only to sender/receiver
encipher (encrypt) - converting plaintext to ciphertext
decipher (decrypt) - recovering plaintext from ciphertext
cryptography - study of encryption principles/methods
cryptanalysis (codebreaking) - the study of principles/ methods of deciphering ciphertext without knowing key
cryptology - the field of both cryptography and cryptanalysis
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1D

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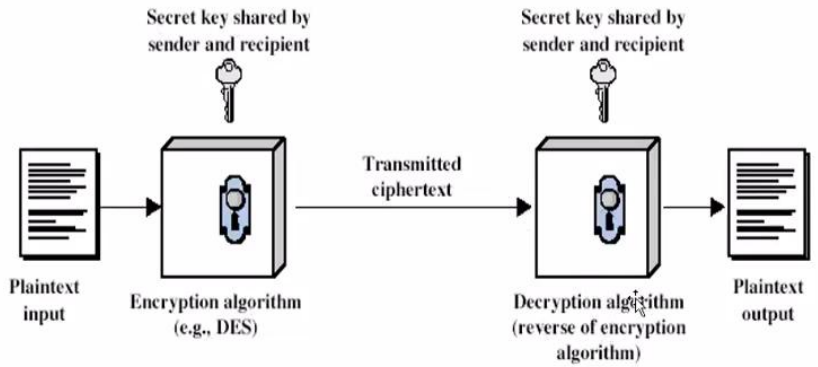
1 2 3 4 5 6 7 8

Symmetric Cipher Model



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Types of Cryptanalytic Attacks

- **Ciphertext only**
  - only know algorithm / ciphertext, statistical, can identify plaintext
- **Known plaintext**
  - know/suspect plaintext & ciphertext to attack cipher
- **Chosen plaintext**
  - select plaintext and obtain ciphertext to attack cipher
- **Chosen ciphertext**
  - select ciphertext and obtain plaintext to attack cipher
- **Chosen text**
  - select either plaintext or ciphertext to en/decrypt to attack cipher

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1 2 3 4 5 6 7 8

Brute Force Search

- always possible to simply try every key
- most basic attack, proportional to key size
- assume either know / recognise plaintext

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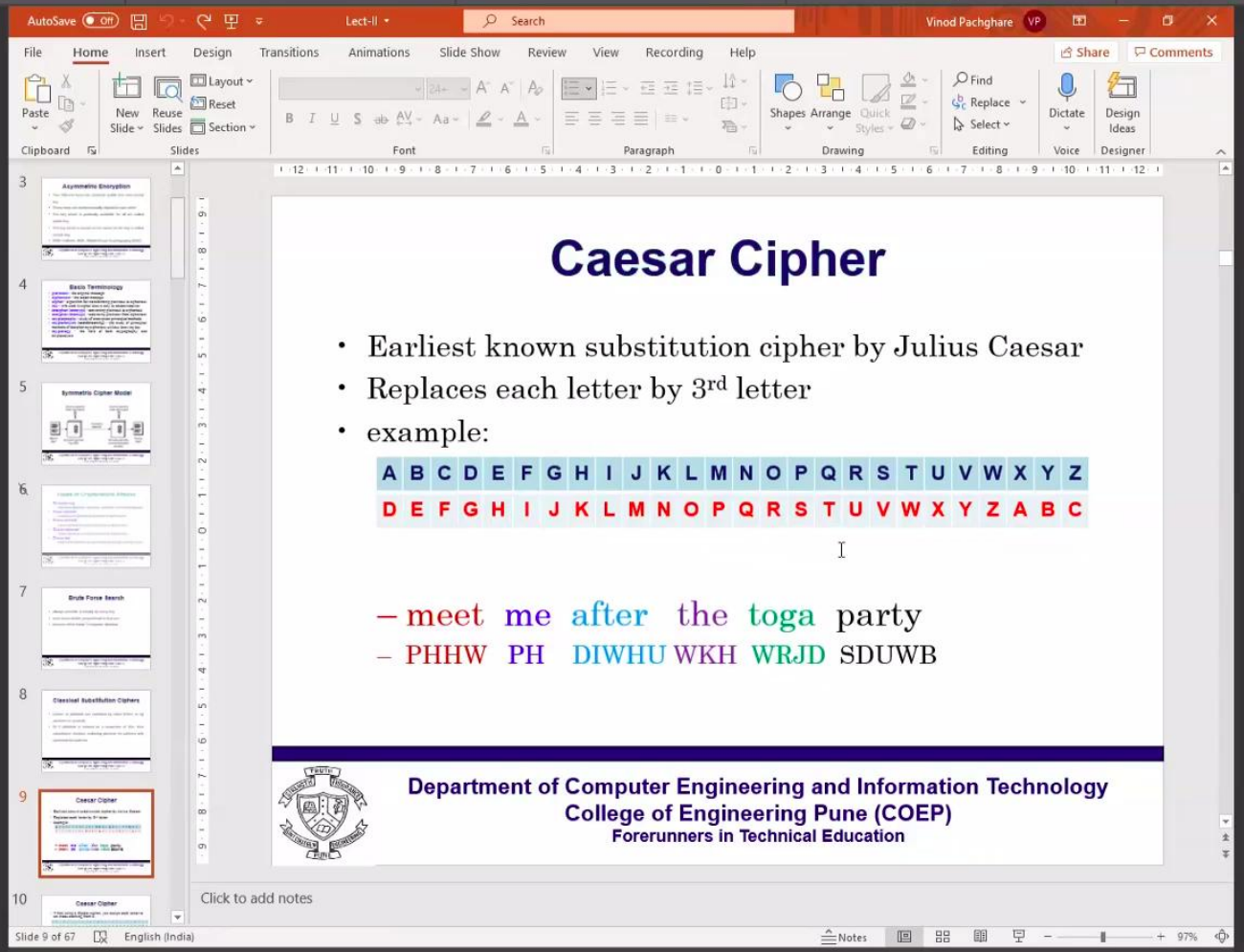

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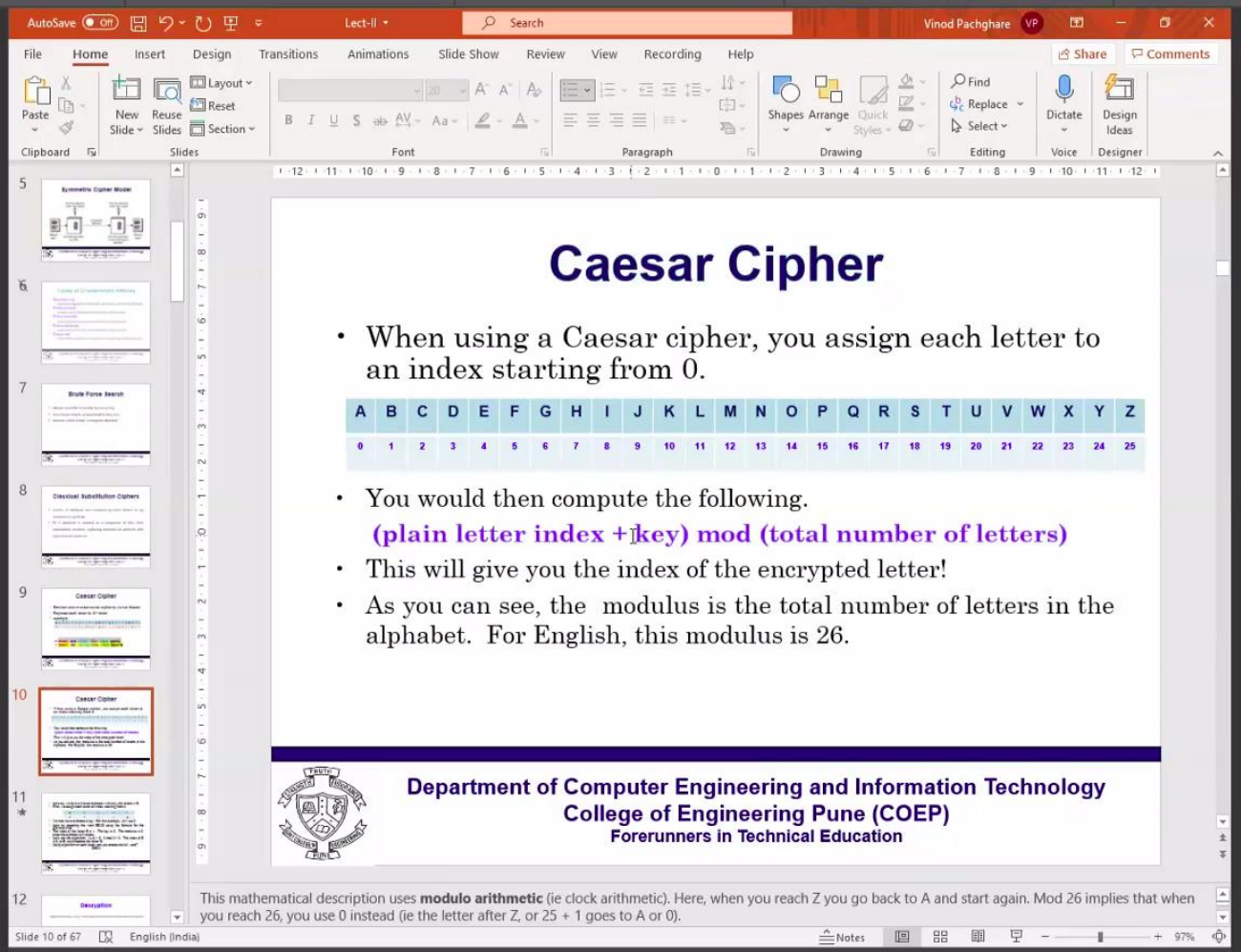

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- Let's say we have a 5 letter alphabet with only the letters A-E
- First, we assign each letter an index, starting from 0.

A	B	C	D	E
0	1	2	3	4

- We then have to choose a key. For this example, we'll use 2.
- Let's try encoding the word BEAD using the formula for the previous slide.
- The index of the letter B is 1. The key is 2. The modulus is 5, since the alphabet is 5 letters.
- Let's use the algorithm: (1+2) = 3. 3 mod 5 = 3. The index of D is 3, so B would become the letter D.
- Using algorithm on each letter, can you encode the full word?

DBCA

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01:01:02 / 01:03:32

1G	4B	1K	1B
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- ***Advantages***
  - This cipher (encryption algorithm) is easy to implement.
- ***Disadvantages***
  - Brute force attack is easily possible.
  - Its observable pattern helps the attacker to find out plaintext easily.
  - Maximum number of keyspace (total number of keys) are 25 which can be easily found out

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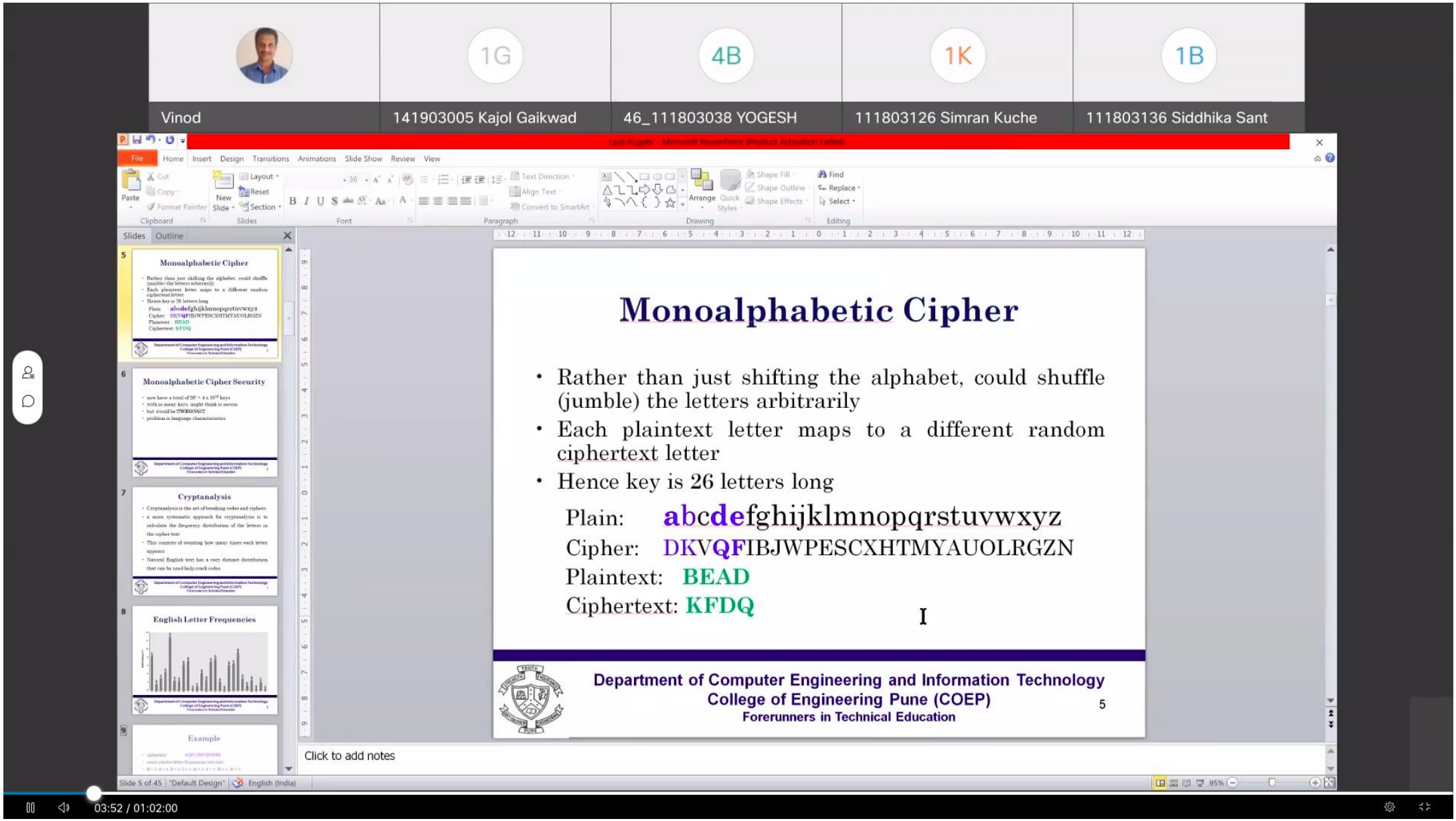
Vinod
1G
141903005 Kajol Gaikwad
4B
46_111803038 YOGESH
1K
111803126 Simran Kuche
1B
111803136 Siddhika Sant
Monoalphabetic Cipher
Rather than just shifting the alphabet, could shuffle (jumble) the letters arbitrarily
Each plaintext letter maps to a different random ciphertext letter
Hence key is 26 letters long
Plain: abcdefghijklmnopqrstuvwxyz
Cipher: DKVQFIBJWPESCXHTMYAUOLRGZN
Plaintext: BEAD
Ciphertext: KFDQ
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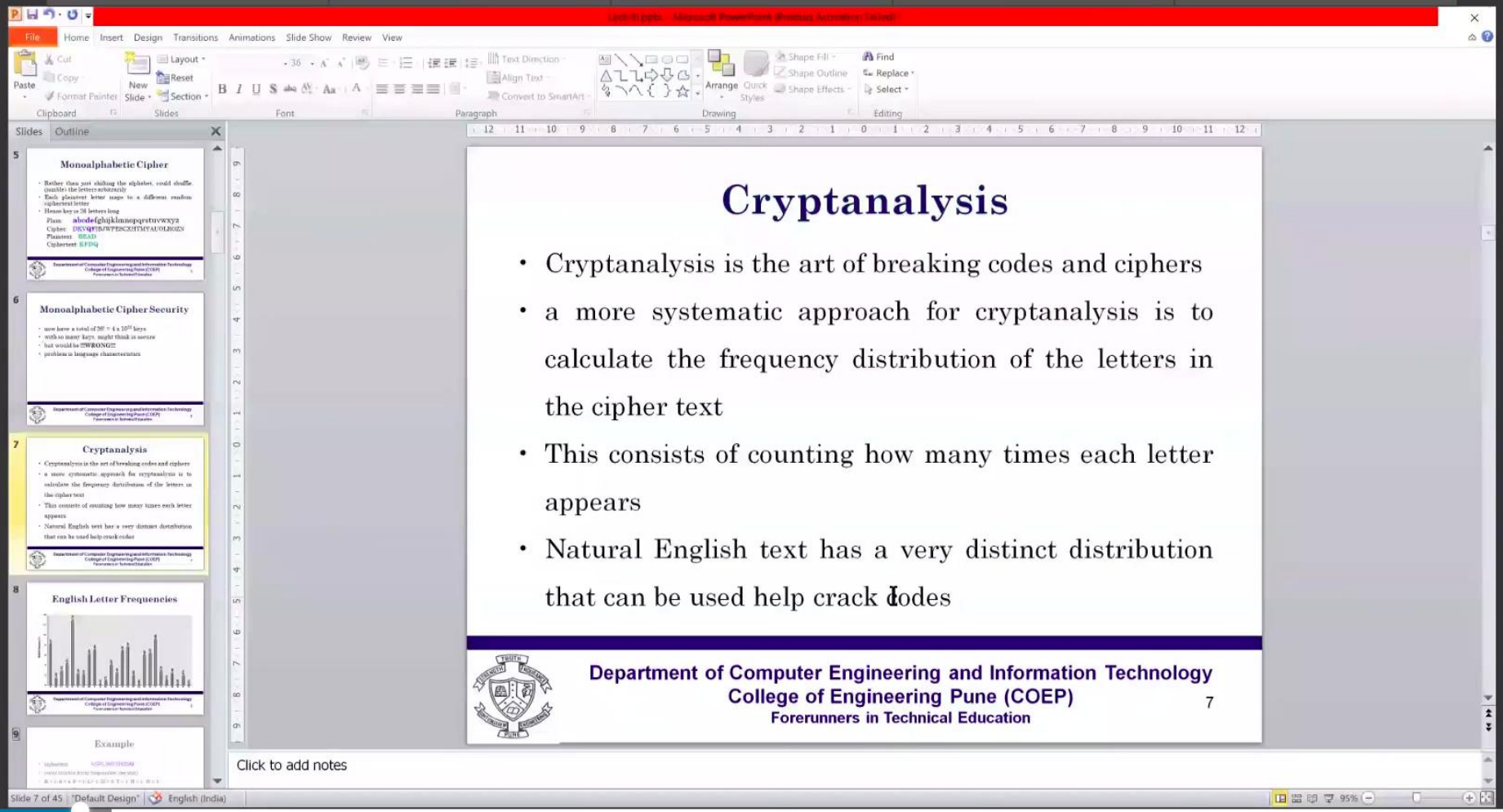

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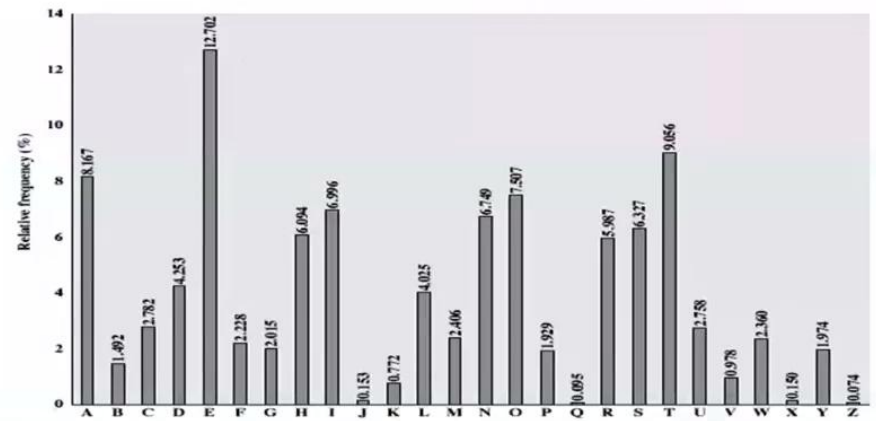
English Letter Frequencies



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08:14 / 01:02:00

	1G	4B	1K	1B
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+115

1G	4B	1K	1B
Vinod	141903005 Kajol Gaikwad	46_111803038 YOGESH	111803126 Simran Kuche	111803136 Siddhika Sant

Monoalphabetic Cipher Security

- now have a total of 26! = 4 x 10^{26} keys
- with so many keys, might think is secure
- but would be **!!!WRONG!!!**
- problem is language characteristics

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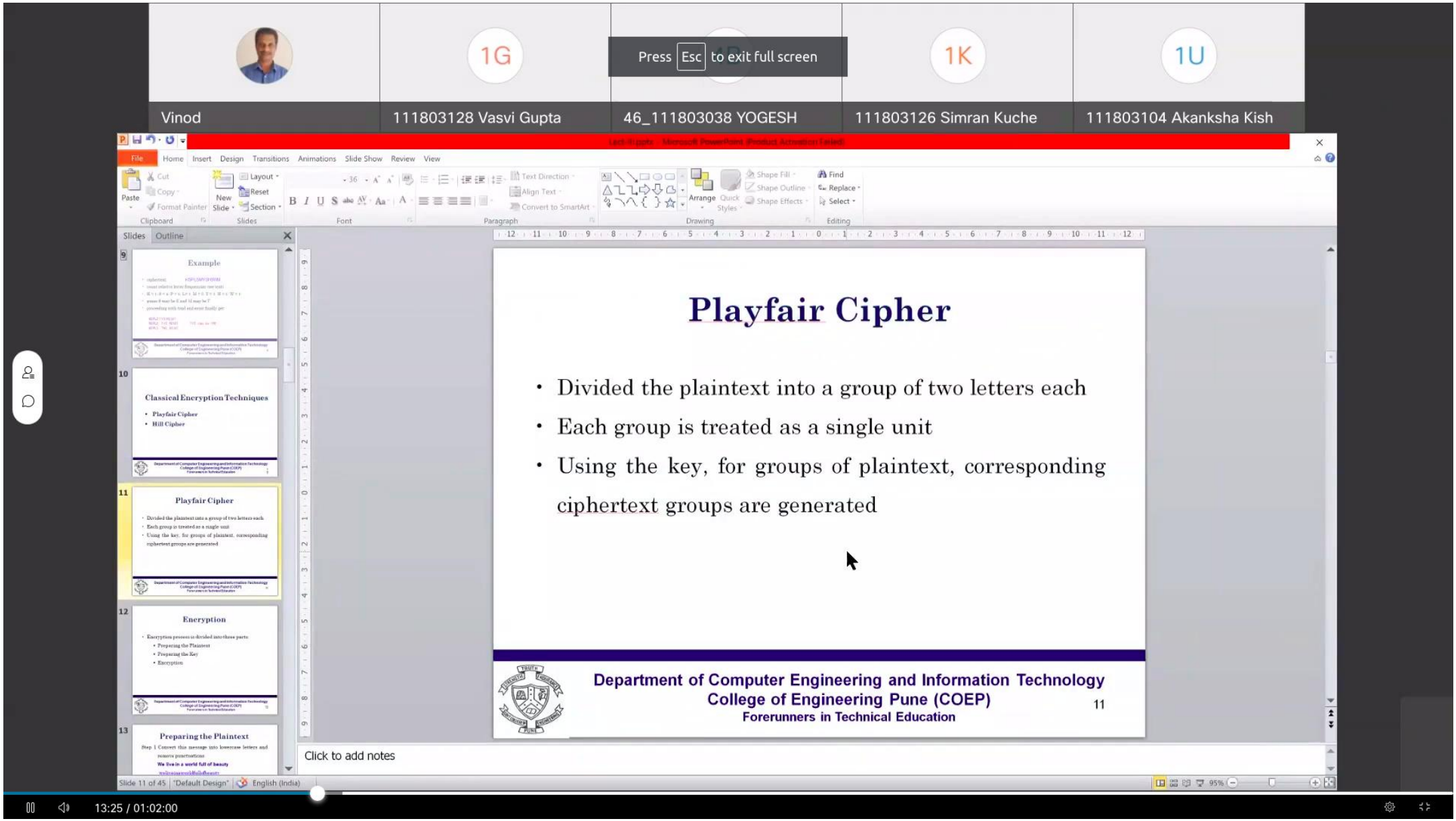
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111803128 Vasvi Gupta
46_111803038 YOGESH
111803126 Simran Kuche
111803104 Akanksha Kish
Playfair Cipher
Divided the plaintext into a group of two letters each
Each group is treated as a single unit
Using the key, for groups of plaintext, corresponding ciphertext groups are generated
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	1G	4B	1K	1U
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Preparing the Plaintext

Step 1 Convert this message into lowercase letters and remove punctuations.

We live in a world full of beauty

weliveinaworldfullofbeauty

Step 2 Split the text into a pair of two.

we li ve in aw or ld fu ll of be au ty

If the last group is having only one letter, then append any one letter in that group to make a pair

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1G

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1K

1P

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Slides Outline

13 Preparing the Plaintext

14

15

16

17 Preparing the Key

Click to add title

- Step 3 Now, write the groups such that in one row 5 pairs are there as shown below:
- If j is present all j are replaced with i. (or any letter)

we	li	ve	in	aw
or	ld	fu	lx	lo
fb	ea	ut	yz	

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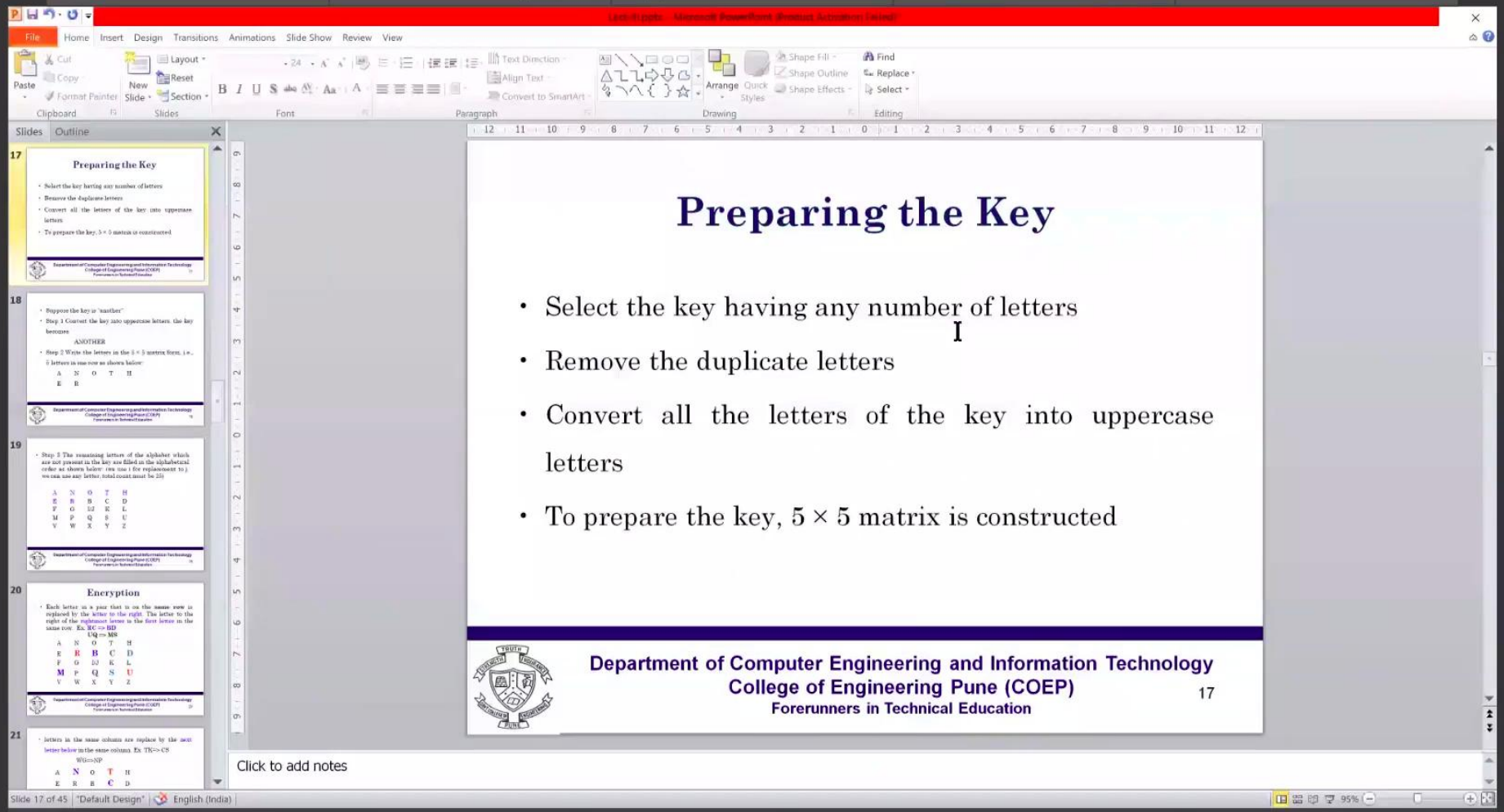
	1G	4B	1K	1P
Vinod	111803128 Vasi Gupta	46_111803038 YOGESH	111803126 Simran Kuche	111803155 VIREN RAJES



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1G	4B	1K	1P
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- Suppose the key is “another”
- Step 1 Convert the key into uppercase letters, the key becomes

  ANOTHER
- Step 2 Write the letters in the 5 × 5 matrix form, i.e., 5 letters in one row as shown below:

A	N	O	T	H
E	R			

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- Step 3 The remaining letters of the alphabet which are not present in the key are filled in the alphabetical order as shown below: (we use i for replacement to j, we can use any letter, total count must be 25)

A	N	O	T	H
E	R	B	C	D
F	G	I/J	K	L
M	P	Q	S	U
V	W	X	Y	Z

1G	1B	1K	1P
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Encryption

- Each letter in a pair that is on the **same row** is replaced by the letter to the right. The letter to the right of the rightmost letter is the first letter in the same row. Ex. **RC => BD**

UQ => MS

A	N	O	T	H
E	**R**	**B**	**C**	**D**
F	G	I/J	K	L
M	P	**Q**	**S**	**U**
V	W	X	Y	Z

- letters in the same column are replace by the next letter below in the same column. Ex. TK=> CS

WG=>NP

A	**N**	O	**T**	H
E	R	B	**C**	D
F	**G**	I/J	**K**	L
M	**P**	Q	**S**	U
V	**W**	X	Y	Z

- when the letters are neither in the same row nor column, the substitution is based upon their intersection
- first move across (left or right), and then up or down.

Ex. **WE => VR**
CZ => DY

A	N	O	T	H
E	**R**	B	**C**	**D**
F	G	I/J	K	L
M	P	Q	S	U
V	**W**	X	**Y**	**Z**

1G	1B	1K	1P
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Encryption

- Each letter in a pair that is on the **same row** is replaced by the letter to the right. The letter to the right of the rightmost letter is the first letter in the same row. Ex. **RC => BD**

UQ => MS

A	N	O	T	H
E	**R**	**B**	**C**	**D**
F	G	I/J	K	L
M	P	**Q**	**S**	**U**
V	W	X	Y	Z

1G	1B	1K	1P
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- letters in the same column are replace by the next letter below in the same column. Ex. TK=> CS

WG=>NP

A	**N**	O	**T**	H
E	R	B	**C**	D
F	**G**	I/J	**K**	L
M	**P**	Q	**S**	U
V	**W**	X	Y	Z

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	1G	1B	1K	1P
Vinod	111803128 Vasvi Gupta	111803143 Rohini Bhonga	111803126 Simran Kuche	111803155 VIREN RAJES

PT:- WE LI VE IN AW OR LD FU LX LO FB EA UT YZ

A	N	O	T	H
E	R	B	C	D
F	G	I/J	K	L
M	P	Q	S	U
V	W	X	Y	Z

CT:- VR FK AF GO NV NB UL LM IZ IH IE FE SH ZV

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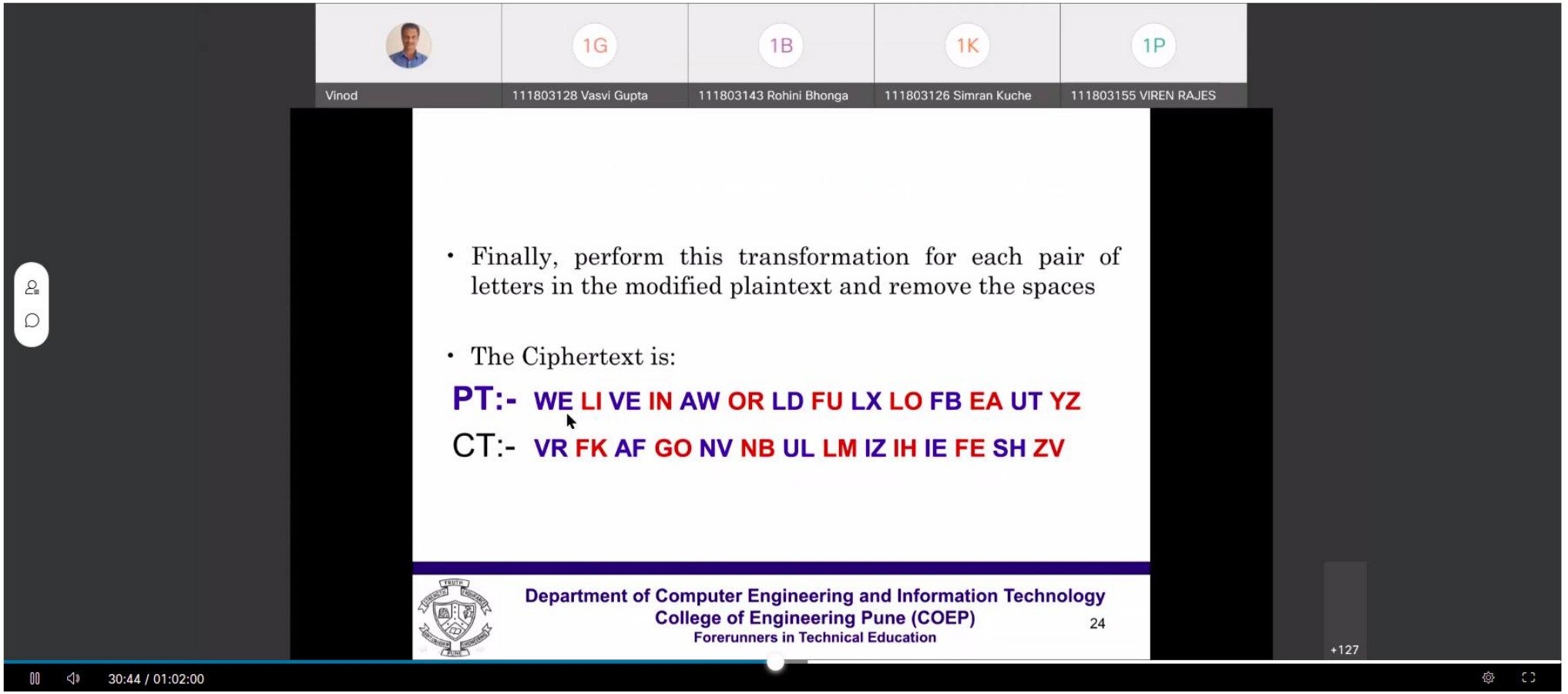

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	1G	1B	1K	1P
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Decryption

- To decrypt the message, simply reverse the entire process. Break the ciphertext into pairs of letters:

VR FK AF GO NV
NB UL LM IZ IH
IE FE SH ZV

Write down the alphabet square with the key:

A	N	O	T	H
E	R	B	C	D
F	G	I/J	K	L
M	P	Q	S	U
V	W	X	Y	Z

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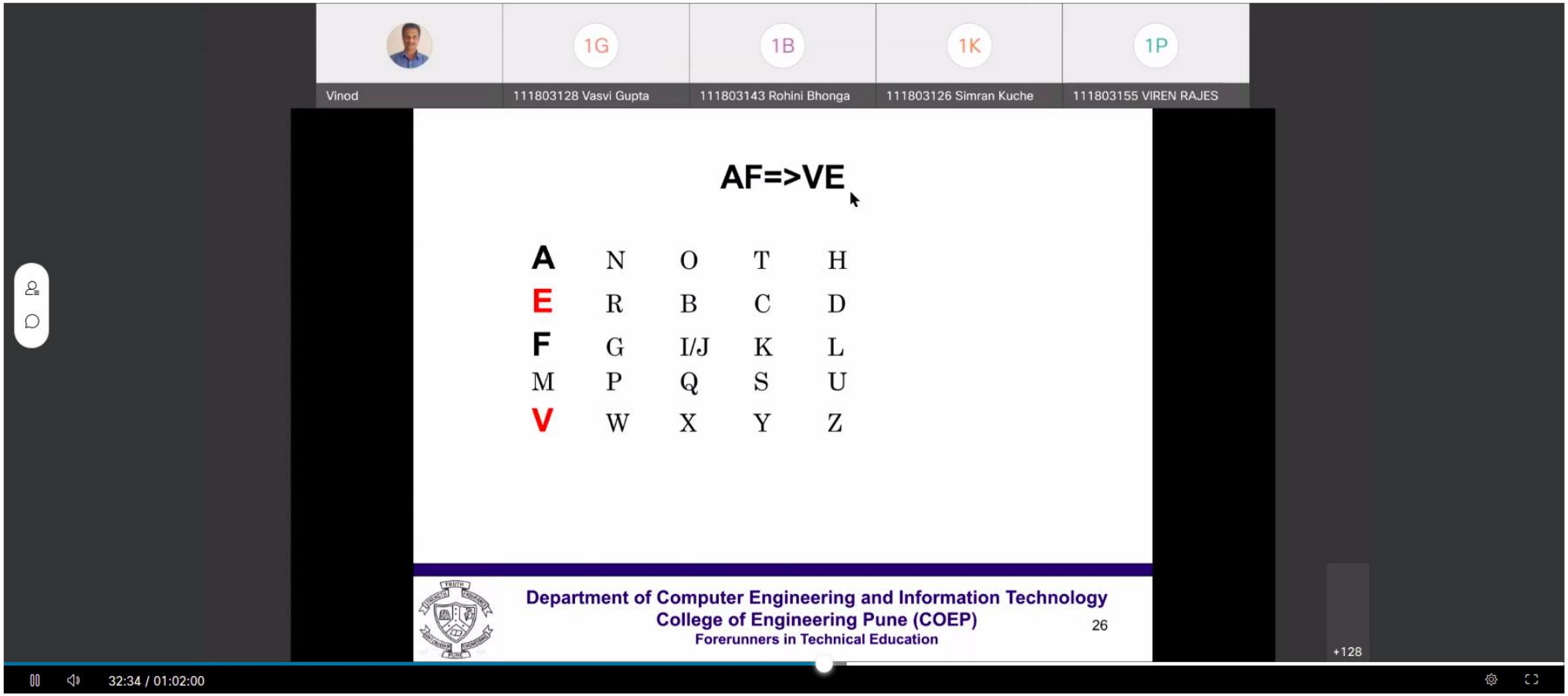

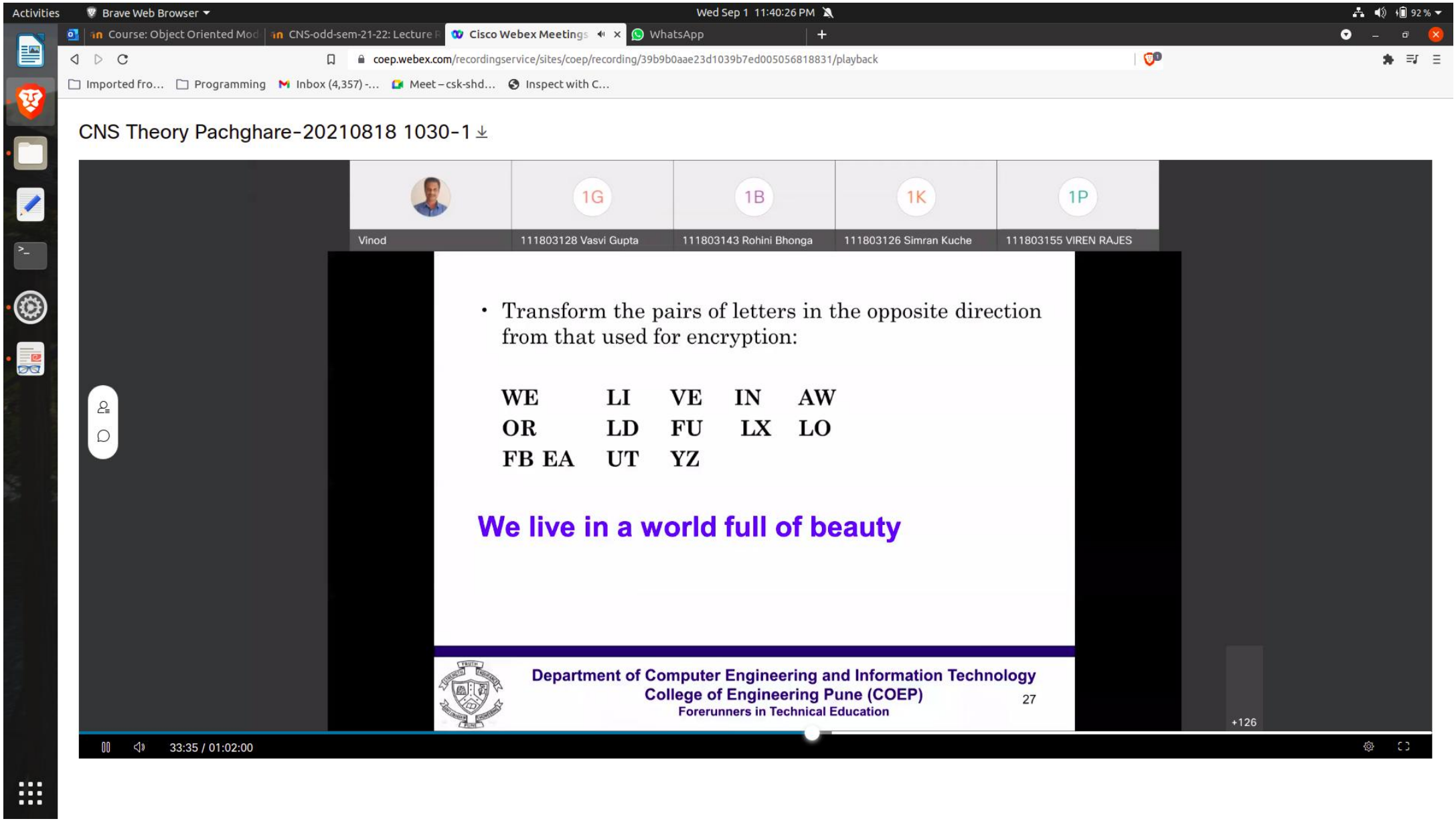
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Vinod
111803128 Vasvi Gupta
111803143 Rohini Bhonga
111803126 Simran Kuche
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• Transform the pairs of letters in the opposite direction from that used for encryption:
WE LI VE IN AW
OR LD FU LX LO
FB EA UT YZ
We live in a world full of beauty
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	1G	1B	1K	1P

The Hill Cipher

- The Hill cipher is a polygraphic substitution cipher based on linear algebra
- Each letter is treated as a digit in base 26: A = 0, B =1, and so on.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

- Consider the message 'COE', and the key below (or "ANOTGERBZ" in letters):
- Ciphertext = Key x Plaintext mod 26

  C = KP mod 26

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	1G	1B	1K	1P
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Encryption

Encryption process is divided into three parts:

- Preparing the Plaintext
- Preparing the Key
- Encryption

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	1G	1B	1K	1P
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Preparing the Plaintext

- First each letter in the message is converted into numbers such as a = 0, b = 1 and so on.
- Then the numbers should be written in columnar form. The number of letters in each column depends on the size of the key matrix.

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	1G	1B	1K	1P
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- Suppose the key matrix is 2 × 2, then each column of plaintext has two elements only.
- Suppose the key matrix is 3 × 3 matrix, then each column of plaintext has three elements only.
- If the last column contains less elements then append necessary numbers to complete the last column.

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	1G	1B	1K	1P
Vinod	111803128 Vasvi Gupta	111803143 Rohini Bhonga	111803126 Simran Kuche	111803155 VIREN RAJES

Preparing the Key

- Key matrix should be a square matrix.
- i,.e. the size of the key must be a square value.
- For example, size of a matrix should be 4 or 9 or 16 etc.
- Every letter in the key is also assigning the number like message.

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	1G	1B	1K	1P
Vinod	111803128 Vasvi Gupta	111803143 Rohini Bhonga	111803126 Simran Kuche	111803155 VIREN RAJES

- The numbers should be written in row wise.
- The number of letters in each row depends on the size of the key matrix.
- Suppose, the key matrix is 2 × 2, then each row having two elements only.
- The key matrix is always a square matrix

like message.

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	1G	1B	1K	1P
Vinod	111803128 Vasvi Gupta	111803143 Rohini Bhonga	111803126 Simran Kuche	111803155 VIREN RAJES

Consider the message 'COE'.

- Since 'C' is 2, 'O' is 14 and 'E' is 4, the message is the vector:

$$P = \begin{bmatrix} 2 \\ 14 \\ 4 \end{bmatrix}$$

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	1G	1B	1K	1P
Vinod	111803128 Vasi Gupta	111803143 Rohini Bhonga	111803126 Simran Kuche	111803155 VIREN RAJES

Encryption

Ciphertext = Key x Plaintext mod 26

C = KP mod 26

$$C = \begin{bmatrix} 0 & 13 & 14 \\ 19 & 6 & 4 \\ 17 & 1 & 25 \end{bmatrix} \begin{bmatrix} 2 \\ 14 \\ 4 \end{bmatrix} = \begin{bmatrix} 238 \\ 138 \\ 148 \end{bmatrix} \bmod 26$$

$$C = \begin{bmatrix} 4 \\ 8 \\ 18 \end{bmatrix}$$

Here the numbers are reconverted into the letters, so, 4 = E, 8 = I, 18 = S. So the ciphertext is 'EIS'.

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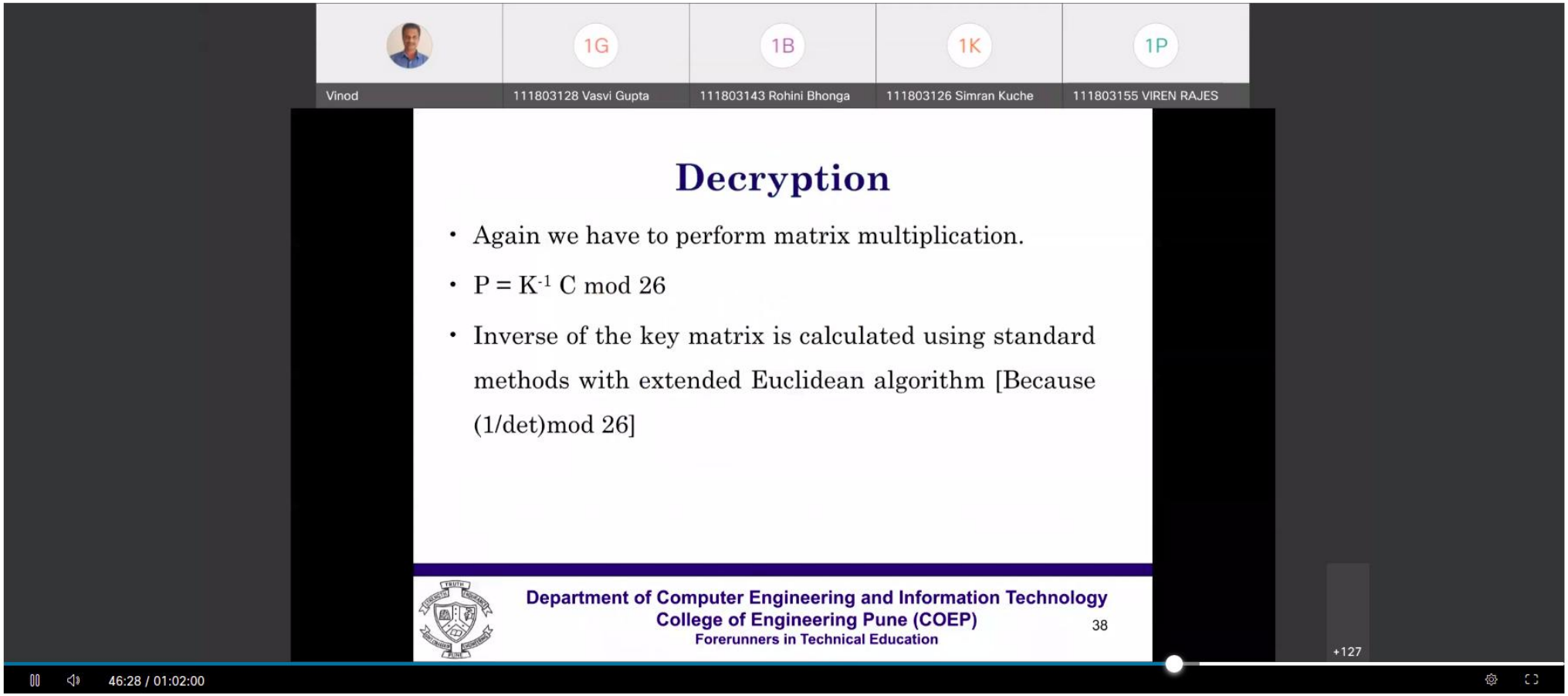

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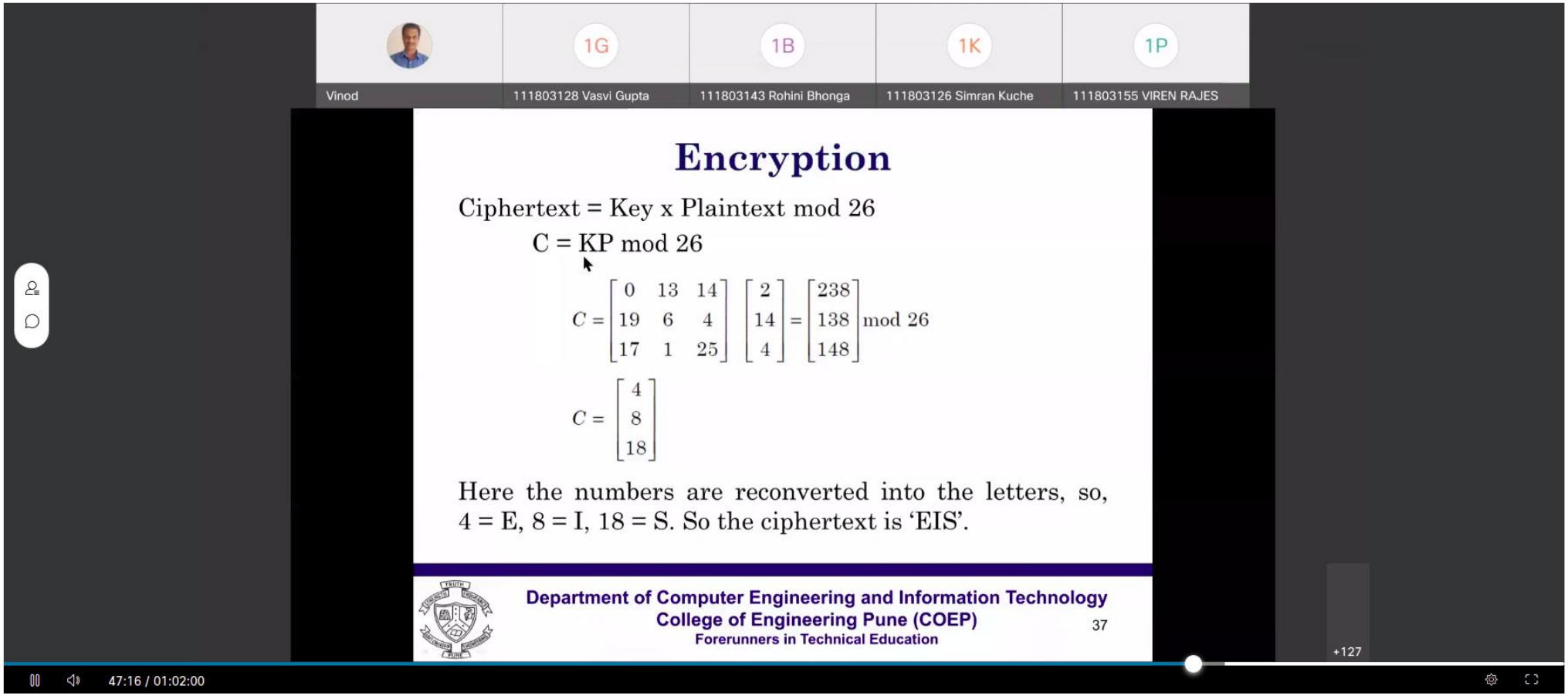

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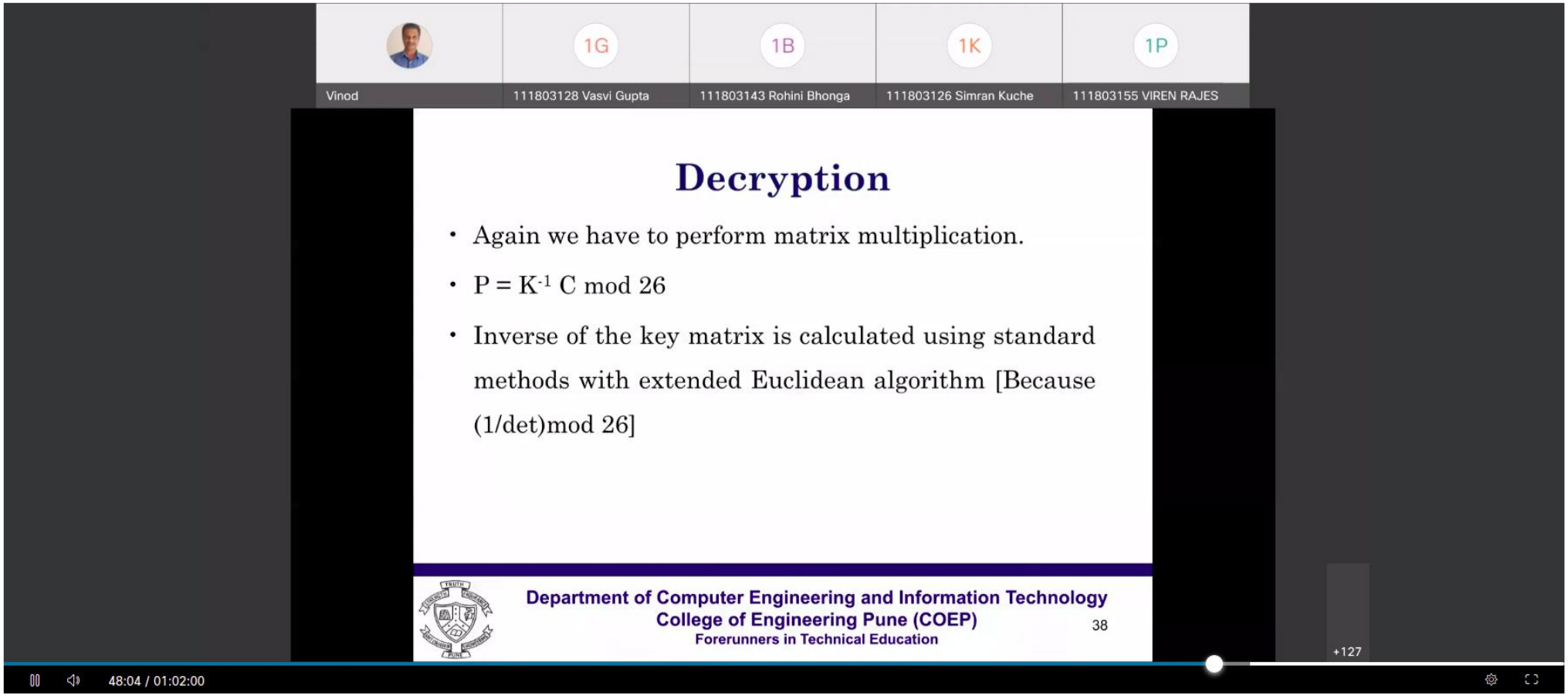

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	1G	1B	1K	1P
Vinod	111803128 Vasvi Gupta	111803143 Rohini Bhonga	111803126 Simran Kuche	111803155 VIREN RAJES

$$P = K^{-1} \times \mathrm{C} \bmod 26$$

$$K^{-1} = \frac{1}{6453}\begin{bmatrix} -146 & 311 & 32 \\ 407 & 238 & -266 \\ 83 & -211 & 247 \end{bmatrix} \bmod 26$$

$$K^{-1} = \frac{1}{6453}\begin{bmatrix} -16 & 25 & 6 \\ 17 & 4 & -6 \\ 5 & -3 & 13 \end{bmatrix} \bmod 26$$

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	1G	1B	1K	1P
Vinod	111803128 Vasi Gupta	111803143 Rohini Bhonga	111803126 Simran Kuche	111803155 VIREN RAJES

Here first compute 6453 mod 26 = 5, then find the multiplicative inverse of 5 such that 5 d mod 26 = 1, where d is the multiplicative inverse of 5.

$$K^{-1} = \frac{1}{5}\begin{bmatrix} -16 & 25 & 6 \\ 17 & 4 & -6 \\ 5 & -3 & 13 \end{bmatrix} \bmod 26$$

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	1G	1B	1K	1P
Vinod	111803128 Vasvi Gupta	111803143 Rohini Bhonga	111803126 Simran Kuche	111803155 VIREN RAJES

Extended Euclidean algorithm

Find out the multiplicative inverse of 5 mod 26

$26 = 5(5) + 1$ $\qquad$ $1 = 26 - 5(5)$

$1 = 26 - 5(5)$
$1 = 26 + 5(-5)]$

-5 is the multiplicative inverse of 5 mod 26 which is equal to (-5 + 26) mod 26 = 21 mod 26

So, 21 is the multiplicative inverse of 5 mod 26

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	1G	1B	1K	1P
Vinod	111803128 Vasvi Gupta	111803143 Rohini Bhonga	111803126 Simran Kuche	111803155 VIREN RAJES

Now replace (1/5) by 21

$$K^{-1} = 21 \begin{bmatrix} -16 & 25 & 6 \\ 17 & 4 & -6 \\ 5 & -3 & 13 \end{bmatrix} \bmod 26$$

$$K^{-1} = \begin{bmatrix} -24 & 5 & 22 \\ 19 & 6 & -22 \\ 1 & -11 & 13 \end{bmatrix} \bmod 26$$

$$K^{-1} = \begin{bmatrix} 2 & 5 & 22 \\ 19 & 6 & 4 \\ 1 & 15 & 13 \end{bmatrix} \bmod 26$$

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	1G	1B	1K	1P
Vinod	111803128 Vasvi Gupta	111803143 Rohini Bhonga	111803126 Simran Kuche	111803155 VIREN RAJES

Advantages

- The ciphertext letter generated for a letter in plaintext is not dependent upon only a single plaintext letter but it is a combination of many letters.
- This helps to avoid the letter frequency problem. It is therefore difficult for cryptanalysis and provides more security.

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	1G	1C	1S	1P
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Disadvantage

- This cipher uses linear algebra, which makes easy for a known plaintext attack

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