SCHEME :K

Name :______________________________

Roll No.:__________ Year : 20 ___ 20 __

Exam Seat No. :______________________

LABORATORY MANUAL FOR NETWORK AND INFORMATION SECURITY (316317)

COMPUTER ENGINEERING GROUP

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI
(Autonomous)(ISO21001:2018)(ISO/IEC27001:2013)

Vision

To ensure that the Diploma level Technical Education constantly matches the latest requirements of Technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

Mission

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes

Core Values

MSBTE believes in the following:

- Skill development in line with industry requirements
- Industry readiness and improved employability of Diploma holders
- Synergistic relationship with industry
- Collective and Cooperative development of all stake holders
- Technological interventions in societal development
- Access to uniform quality technical education

A Practical Manual

For

Network and Information Security

(316317)

Semester-VI

CM/ CO/ CW / IF/ BD/ SE

Maharashtra State Board of Technical Education, Mumbai

(Autonomous) (ISO 21001:2018)(ISO/IEC 27001:2013)

'K' Scheme Curriculum

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

(Autonomous) (ISO 21001:2018)(ISO/IEC 27001:2013)

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Maharashtra State Board of Technical Education

Certificate

This is to certify that Mr./ Ms ………………………………………………… Roll No………..…... of…………………………Semester of Diploma in………...……………………………………….............of **Institute Name** ………..……....……………………………….(**Inst. Code:**…….……...) has completed the term work satisfactorily in Course **Network and Information Security (Course Code:316317)** for the academic year 20……. to 20……. as prescribed in the curriculum.

Place ……………….   Enrollment No……………………

Date: …....................   Exam Seat No. …………………......

Course Teacher   **Head of the Department**   **Principal**

Seal of
the
Institute

Preface

The primary focus of any engineering laboratory/field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'K' Scheme curricula for engineering Diploma programmes with outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher, instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a 'vehicle' to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the “K” scheme laboratory manual development team designed the practical's to focus on outcomes, rather than the traditional age old practice of conducting practical's to verify the theory (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read the concerned practical procedure that they will do the next day and understand minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. Students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Operating systems are an essential part of any computer system. Similarly, a course on operating systems is an essential part of any computer group. We hope that students will also find it useful. It provides a clear description of practical performance, execution and working of Operating System.

Although all care has been taken to check for mistakes in this laboratory manual, yet it is impossible to claim perfection especially as this is the first edition. Any such errors and suggestions for improvement can be brought to our notice and are highly welcome.

Program Outcomes (POs) to be achieved through Course:

PO1	Basic and Discipline specific knowledge: Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the engineering problems.
PO2	Problem analysis: Identify and analyses well-defined engineering problems using codified standard methods.
PO3	Design/ development of solutions: Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.
PO4	Engineering Tools, Experimentation and Testing: Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.
PO5	Engineering practices for society, sustainability and environment: Apply appropriate technology in context of society, sustainability, environment and ethical practices.
PO6	Project Management: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.
PO7	Life-long learning: Ability to analyses individual needs and engage in updating in the context of technological changes.

List of Relevant Skills

The following industry-relevant skills of the competency “Implement Network and Information Security Mechanisms” are expected to be developed in you by performing the practicals of this laboratory manual:

1. Configure and manage antivirus software and apply privacy and security settings on operating systems.
2. Implement user authentication techniques such as password recovery, access control, and multi-factor authentication.
3. Apply cryptographic algorithms (e.g., Caesar, Vernam, Rail Fence, Columnar Transposition) for data encryption and decryption.
4. Generate and verify digital signatures, hash codes, and digital certificates using open-source tools.
5. Configure and analyze firewall settings and implement secure email communication using encryption tools.
6. Use steganography techniques to securely embed and extract messages within digital media.
7. Identify and mitigate network and database security threats using security tools and protocols (e.g., IDS, Kerberos, IPsec).

Practical Course Outcome Matrix

Course Outcomes (COs)

CO1	Identify types of Cyber attacks and threats.
CO2	Apply multi-factor user authentication and access control.
CO3	Implement encryption/decryption techniques.
CO4	Use tools and techniques to prevent cyber attacks.
CO5	Apply security on Network and Database.

Sr. No.	Title of the Experiment	CO1	CO2	CO3	CO4	CO5
1	* i.Install and configure Antivirus software on system (Licensed copy) ii. Use privacy and security settings on operating system	✓				
2	* i. Set up single level authentication for computer system ii. Recover the password of computer system using any freeware password recovery tool (Example- John the ripper).		✓			
3	* i. Grant security to file, folder or application using access permissions and verify it ii. Grant access permission while sharing file and folder		✓			
4	* Write a utility using C/Shell programming to create strong password authentication (Password should be more than 8 characters, and combination of digits, letters and special characters #, %, &, @)		✓			
5	* i. Write a C program to implement caesar cipher technique to perform encryption and decryption of text ii. Apply Caesar cipher technique to perform encryption and decryption of text using any open-source tool (Example - Cryptool)			✓		
6	i. Implement Vernam cipher encryption technique to perform encryption of text using C programming language ii. Apply Vernam cipher technique to perform encryption and decryption of text using any open-source tool (Example - Cryptool)			✓		

7	Implement railfence encryption technique to perform encryption of text using C programming language			✓		
8	Implement simple Columnar Transposition encryption technique to perform encryption of text using C programming language			✓		
9	* Create and verify Hash Code for given message using any Open-source tool (Example-Cryptool)			✓		
10	i. Write a C program to implement Diffie-Hellman key exchange algorithm to perform encryption of text ii. Use Diffie-Hellman key exchange algorithm to perform encryption and decryption of text using any open-source tool (Example - Cryptool)				✓	
11	* Use Steganography to encode and decode the message using any open-source tool (Example-OpenStego)				✓	
12	* Create and verify digital signature using any Open- source tool (Example-Cryptool)				✓	
13	Create and verify digital Certificate using any Open- source tool (Example-Cryptool).				✓	
14	Configure firewall settings on any operating system.				✓	
15	* Send a test mail securely using any open-source tool (Example- Pretty Good Privacy with GnuPG)					✓
16	Find the origin of email using email tracker pro.					✓

Guidelines to Teachers

1. Teachers should align the explanation of the topic to teaching learning outcome (TLOs).
2. Refer to laboratory learning outcome (LLOs) for the execution of the practical to focus on the defined objectives.
3. Promote life-long learning by training the students to equip themselves with essential knowledge, skills and attitudes.
4. If required, provide demonstration for the practical emphasizing on the skills that the student should achieve.
5. Teachers should give opportunity to the students for exhibiting their skills after the demonstration.
6. Provide feedback and/or suggestions and share insights to improve effectiveness.
7. Assess students' skill achievement related to COs of each unit.

Instructions for Students

1. 100% attendance is compulsory for all practical sessions.
2. Students must adhere to ethical practices.
3. All the students must follow the schedule of practical sessions, complete the assigned work/activity and submit the assignment in stipulated time as instructed by the course teacher.
4. Students shall listen carefully the lecture given by teacher about importance of subject, learning structure, course outcomes.
5. Students shall understand the purpose of experiment and its practical implementation.
6. Students shall write the answers of the questions during practical.
7. Student should feel free to discuss any difficulty faced during the conduct of practical.
8. Student shall attempt to develop related hands-on skills and gain confidence.
9. Students should develop habit to submit the write-ups on the scheduled dates and time.

Content Page

List of Practical and Formative Assessment Sheet

Sr. No	Practical Title	Date of Performance	Date of Submission	Assessment Marks (25)	Teacher Sign	Remark
1	* i.Install and configure Antivirus software on system (Licensed copy) ii. Use privacy and security settings on operating system					
2	* i. Set up single level authentication for computer system ii. Recover the password of computer system using any freeware password recovery tool (Example- John the ripper).					
3	* i. Grant security to file, folder or application using access permissions and verify it ii. Grant access permission while sharing file and folder					
4	* Write a utility using C/Shell programming to create strong password authentication (Password should be more than 8 characters, and combination of digits, letters and special characters #, %, &, @)					
5	* i. Write a C program to implement caesar cipher technique to perform encryption and decryption of text ii. Apply Caesar cipher technique to perform encryption and decryption of text using any open-source tool (Example - Cryptool)					
6	i. Implement Vernam cipher encryption technique to perform encryption of text using C programming language ii. Apply Vernam cipher technique to perform encryption and decryption of text using any open-source tool (Example - Cryptool)					

7	Implement railfence encryption technique to perform encryption of text using C programming language					
8	Implement simple Columnar Transposition encryption technique to perform encryption of text using C programming language					
9	* Create and verify Hash Code for given message using any Open-source tool (Example-Cryptool)					
10	i. Write a C program to implement Diffie-Hellman key exchange algorithm to perform encryption of text ii. Use Diffie-Hellman key exchange algorithm to perform encryption and decryption of text using any open-source tool (Example - Cryptool)					
11	* Use Steganography to encode and decode the message using any open-source tool (Example-OpenStego)					
12	* Create and verify digital signature using any Open- source tool (Example-Cryptool)					
13	Create and verify digital Certificate using any Open- source tool (Example-Cryptool).					
14	Configure firewall settings on any operating system.					
15	* Send a test mail securely using any open-source tool (Example- Pretty Good Privacy with GnuPG)					
16	Find the origin of email using email tracker pro.					
Total						

***Total marks to be transferred to proforma published by MSBTE**

Note:
- '*' Marked Practical's (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

Practical No. 01: i. Install and configure Antivirus software on system (Licensed copy) ii. Use privacy and security settings on operating system

I. Practical Significance

This practical demonstrates installation, activation, configuration, and testing of antivirus software, along with applying operating system security updates and settings. Antivirus and patching form the first line of defence against malware, viruses, worms, and exploits. By combining endpoint protection with OS security updates, organizations can significantly reduce vulnerabilities.

II. Industry / Employer Expected Outcome

Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO1 - Identify types of Cyber attacks and threats.

IV. Laboratory Learning Outcome (LLO)

LLO 1.1 Install Antivirus software on system.
LLO 1.2 Apply privacy and security settings to protect operating system.

V. Relevant Affective domain related Outcomes(s)

1. Responsibility: following institutional security policy when configuring systems.
2. Attention to detail: verifying update settings and scheduled scans.
3. Ethical awareness: only using licensed software and not circumventing controls.

VI. Theoretical Background

Antivirus software is a security application designed to detect, prevent, and remove malware such as viruses, worms, Trojans, spyware, ransomware, and rootkits. It works by scanning files, monitoring system behaviour, and comparing data against a database of known malware signatures.
Since operating systems and applications are constantly at risk of malicious attacks, antivirus provides a first line of defence. It prevents unauthorized code from executing, safeguards sensitive data, and ensures the system remains operational.
Operating system security is the process of implementing measures to protect OS resources such as files, memory, processes, and user accounts from unauthorized access and misuse. Privacy and security settings ensure confidentiality, integrity, and availability (CIA triad) of the system and user data.
Every OS has default settings that may expose vulnerabilities. By customizing and strengthening privacy/security configurations, we minimize risks like malware infection, identity theft, unauthorized data access, and insider misuse.

VII. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows XP / 7 onwards / LINUX V 5.0 or latest		
3	Tools / Software Required	Antivirus software,(Quick Heal)		

VIII. Procedure

Install and Configure Antivirus Software in Your System

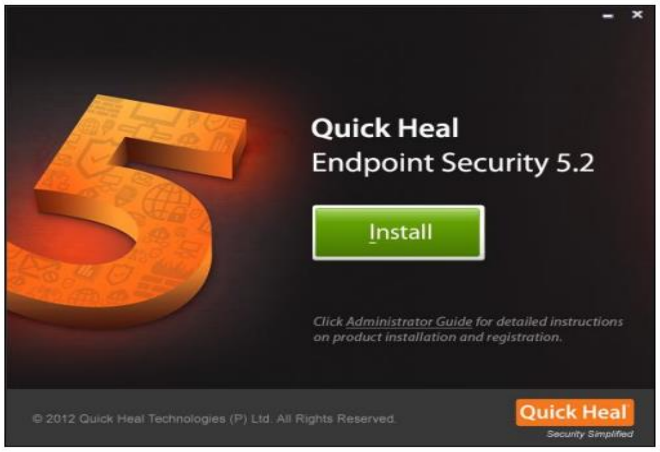
We will install **Quick Heal Antivirus** using the Quick Heal CD or by downloading the Quick Heal Installer from www.quickheal.co.in.

A. Using Quick Heal CD

1. Insert the Quick Heal antivirus CD/DVD in the DVD drive.
2. Click **Install**.
3. Follow the on-screen instructions.

B. Using Quick Heal Installer

1. Download the Quick Heal antivirus from:
   https://www.quickheal.co.in/quick-heal-product-installer
2. Double-click the downloaded product setup.
3. Follow the on-screen instructions to complete the installation.



Click Administrator Guide for detailed instructions on product installation and registration.

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Part B: Register Quick Heal Antivirus

To enjoy full benefits and configurations of Quick Heal, you must register the product online.

1. Open **Quick Heal Antivirus**.
2. On the Quick Heal Dashboard, click the **Register Now** button.
3. On the Registration Wizard, enter the **20-digit Product Key** and click **Next**.
4. The Registration Information window will appear.

5. Enter details in the **Purchased From** and **Register For** text boxes, then click **Next**.
6. Provide your **Name, Email Address, and Contact Number**.
   - Select your **Country, State, and City**.
   - If your State/Province or City is not in the list, type it manually in the respective box.
7. Click **Next** to continue.
8. A confirmation screen will appear with the details entered.
   - If corrections are needed, click **Back** to edit.

Part C: Activate and Configure Scanning

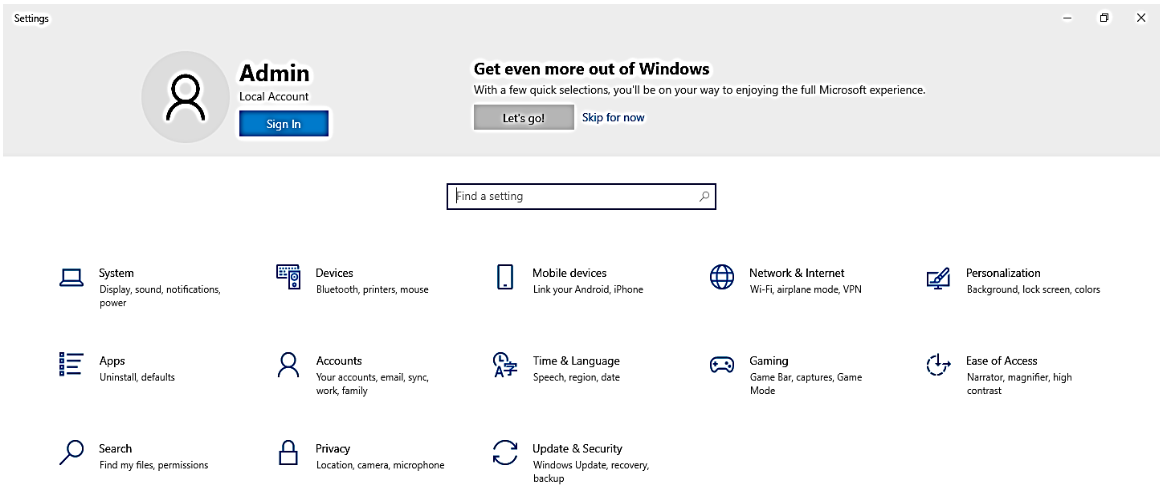
1. Click **Next** to continue.
2. The product will be activated successfully. The **expiry date of your license** will be displayed.
3. Click **Finish** to close the Registration Wizard.
4. Quick Heal will automatically perform a **full system scan**.
5. A window will prompt you to:
   - Select how frequently you want your system to be scanned.
   - Select the type of scan.
6. Click **Finish** to apply the settings.

Use Privacy and Security Settings on Operating System

Privacy and security settings protect your system, data, and online activity from unauthorized access or malicious attacks. Modern operating systems like **Windows 10/11** and **Windows 7/8** provide built-in tools to configure these settings.

Steps for Windows 10/11

1. **Open Settings**
   - Press **Windows + I** keys together or click the **Start** menu → **Settings**.


Settings
Admin
Local Account
Sign In
Get even more out of Windows
With a few quick selections, you'll be on your way to enjoying the full Microsoft experience.
Let's go!
Skip for now
Find a setting
System
Display, sound, notifications, power
Devices
Bluetooth, printers, mouse
Mobile devices
Link your Android, iPhone
Network & Internet
Wi-Fi, airplane mode, VPN
Personalization
Background, lock screen, colors
Apps
Uninstall, defaults
Accounts
Your accounts, email, sync, work, family
Time & Language
Speech, region, date
Gaming
Game Bar, captures, Game Mode
Ease of Access
Narrator, magnifier, high contrast
Search
Find my files, permissions
Privacy
Location, camera, microphone
Update & Security
Windows Update, recovery, backup

2. **Navigate to Privacy Settings**
   - In the Settings window, click **Privacy**.
   - Review options such as:
     - **Location** – Turn off if you don't want apps to track your location.
     - **Camera & Microphone** – Choose which apps can access these.
     - **Activity History** – Disable if you don't want Windows to collect usage data.
     - **Background Apps** – Turn off unnecessary apps to reduce tracking.

3. **Navigate to Security Settings**
   - In the Settings window, go to **Update & Security → Windows Security**.
   - Configure:
     - **Virus & Threat Protection** – Ensure Windows Defender or another antivirus is active.
     - **Firewall & Network Protection** – Keep the firewall turned ON for all networks.
     - **App & Browser Control** – Enable SmartScreen for safer browsing.
     - **Device Security** – Check hardware security features.
4. **Set Login and Account Security**
   - Go to **Accounts → Sign-in Options**.
   - Set a **Strong Password** or use **Windows Hello (PIN, fingerprint, or face recognition)**.
   - Enable **Two-Factor Authentication (2FA)** for your Microsoft Account.

Steps for Windows 7/8/8.1

1. Open **Control Panel → Action Center**.
2. Click **Security** tab and check:
   - **Windows Update** – Turn ON automatic updates.
   - **Windows Firewall** – Ensure it is enabled.
   - **Virus Protection** – Make sure antivirus is installed and active.
   - **Internet Security Settings** – Use recommended levels for safer browsing.
   - **User Account Control (UAC)** – Keep it ON for permission prompts when apps make changes.
3. Open **Privacy Settings**:
   - Disable location services if not needed.
   - Manage app permissions through installed applications.

IX. Precautions

1. Use legitimate license keys only.
2. Do not interrupt updates mid-way.
3. If system fails to boot after update, revert snapshot/restore.
4. Use isolated test environment when experimenting.
5. During lab, do not perform other simultaneous installations to avoid conflicts.

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. State the purpose of antivirus software?
2. Difference between a quick scan and a full scan in antivirus software.
3. Demonstrate how to check and install pending OS updates on your system.
4. Compare antivirus protection with firewall defence. How do they complement each other?
5. Design a basic security policy for a workstation that includes antivirus, firewall, and OS updates

Space for Answer

……………………………………………………………………………………………......

……………………………………………………………………………………………......

XI. Exercise

1. Install and configure NP (Net Protector) on a system and schedule a scan.
2. Enable and disable Windows Firewall; analyze the changes in inbound/outbound connections.
3. Apply OS updates and generate a report/log of update history.

XII. References / Suggestions for further reading

1. Stallings, W. & Brown, L., 2014. Computer Security: Principles and Practice. Pearson. Publisher link
2. Administrator Guide Quick Heal Endpoint Security 5.2. Available at: https://dlupdate.quickheal.com/documents/manual/eps5.2_userguide.pdf
3. YouTube, 2020. Firewall Configuration Tutorial. Available at: https://www.youtube.com/watch?v=T9c5ZpT2FV0
4. NPTEL, 2022. Introduction to Information Security. Available at: https://archive.nptel.ac.in/courses/106/106/106106129/
5. Virtual Labs, IIIT Hyderabad, n.d. Cryptography Experiments. Available at: https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html

XIII. Assessment schemes

Performance Indicators		Weightage
Process related (15 Marks)		**60 %**
1	Following correct installation procedure of Antivirus	20 %
2	Configuring scans, updates, and OS security settings	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Quality of Output (Antivirus installed, updated, OS patched, firewall active)	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 02: i. Set up single level authentication for computer system ii. Recover the password of computer system using any freeware password recovery tool (Example- John the ripper)

I. Practical Significance

This practical demonstrates the importance of authentication and password management in computer systems. Single-level authentication ensures that only authorized users can access the system, while password recovery tools help administrators recover lost credentials. Understanding authentication mechanisms and recovery methods is crucial for maintaining system availability and security.

II. Industry / Employer Expected Outcome

Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO2 – Apply multi-factor user authentication and access control.

IV. Laboratory Learning Outcome (LLO)

LLO 2.1 Setup and recover password of computer system.

V. Relevant Affective domain related Outcomes(s)

1. Responsibility: applying authentication policies securely.
2. Attention to detail: ensuring correct configuration of authentication and recovery tools.
3. Ethical awareness: using password recovery tools only for authorized and legitimate purposes.

VI. Theoretical Background

Authentication is the process of verifying the identity of a user or system. Single-level authentication typically involves using a username and password. Weak or lost passwords can make systems vulnerable, hence recovery mechanisms are needed.

Password recovery tools such as John the Ripper or Ophcrack use techniques like dictionary attacks, brute force, or rainbow tables to crack passwords. While they can be misused, they are essential for administrators in recovery and auditing scenarios.

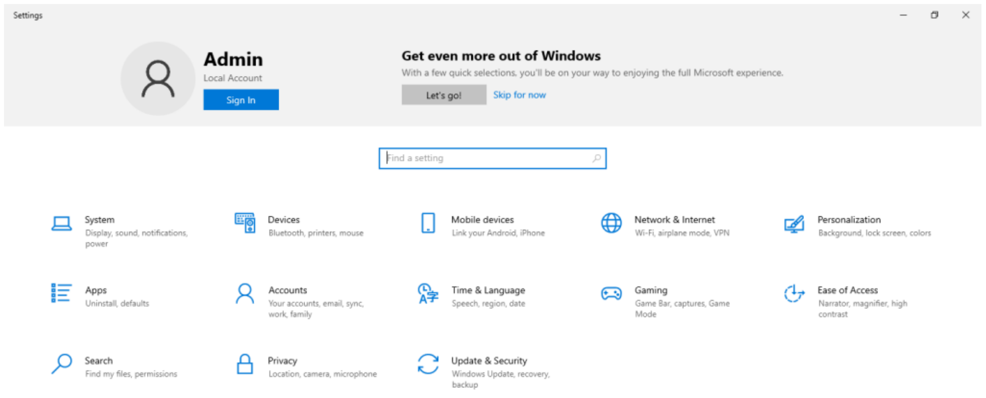
VII. Resources required:

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows XP / 7 onwards / LINUX V 5.0 or latest		
3	Tools / Software Required	John the Ripper		

VIII. Procedure

Steps to Set Up Single Level Authentication (Windows 10/11)

1. **Open Settings**
   - Press **Windows Key + I**
   - OR click **Start → Settings**
2. **Go to Accounts**
   - In the Settings window, click **Accounts**
3. **Access Sign-in Options**
   - From the left menu, select **Sign-in options**
4. **Create a Password**
   - Under **Password**, click **Add** (if no password is set)
   - Enter a **new password**
   - Confirm the password
   - Add a **Password Hint** (to help if you forget it)
   - Click **Next → Finish**
5. **Require Sign-in at Startup**
   - In **Sign-in options**, under **Require sign-in**, choose **When PC wakes up from sleep**
   - This ensures authentication is required every time the system starts or wakes.
6. **Lock and Test**
   - Press **Windows + L** to lock the computer.
   - Try logging in with the new password to confirm setup.


Settings
Admin
Local Account
Sign In
Get even more out of Windows
With a few quick selections, you'll be on your way to enjoying the full Microsoft experience.
Let's go!
Skip for now
Find a setting
System
Display, sound, notifications, power
Devices
Bluetooth, printers, mouse
Mobile devices
Link your Android, iPhone
Network & Internet
Wi-Fi, airplane mode, VPN
Personalization
Background, lock screen, colors
Apps
Uninstall, defaults
Accounts
Your accounts, email, sync, work, family
Time & Language
Speech, region, date
Gaming
Game Bar, captures, Game Mode
Ease of Access
Narrator, magnifier, high contrast
Search
Find my files, permissions
Privacy
Location, camera, microphone
Update & Security
Windows Update, recovery, backup

Steps for Windows 7 / 8 / 8.1

1. Open **Control Panel → User Accounts → Create a password for your account**
2. Enter a **strong password** and confirm it.
3. Click **Create Password**.
4. Restart or lock (**Win + L**) to test login authentication.

Recover the password of computer system using any freeware password recovery tool (Example- John the ripper)

A — Prepare (common prerequisites)

1. Use an isolated **lab VM** (snapshot before you begin).
2. Download John the Ripper (jumbo build recommended) for Windows: https://www.openwall.com/john/ and unzip it.

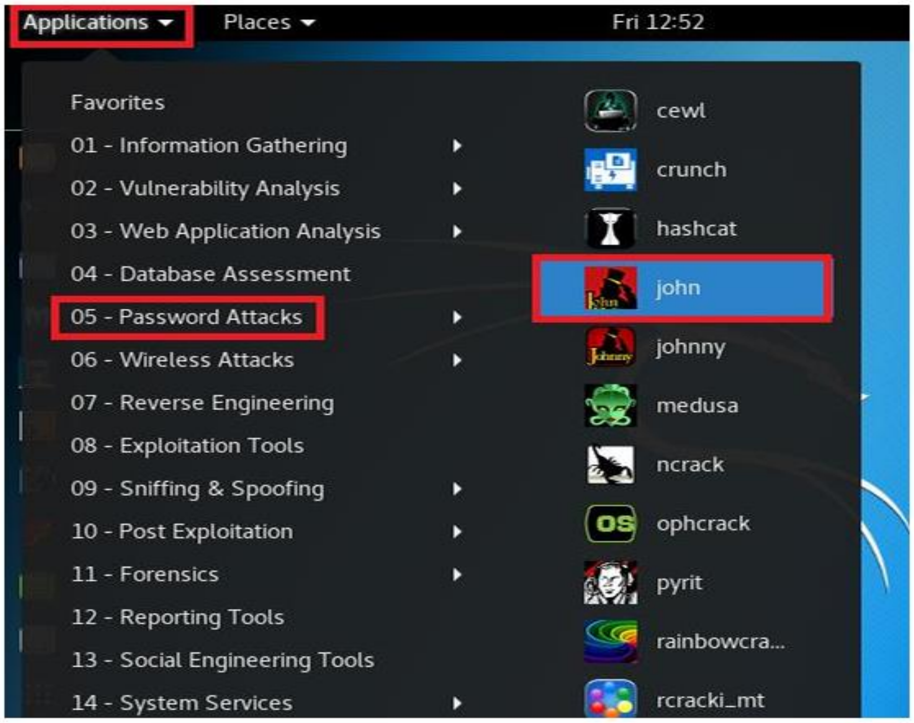
3. Obtain a wordlist (e.g. rockyou.txt or other wordlists). Place it in the John run folder or note its path.

PASSWORD CRACKING WITH JOHN-THE-RIPPER TOOL:

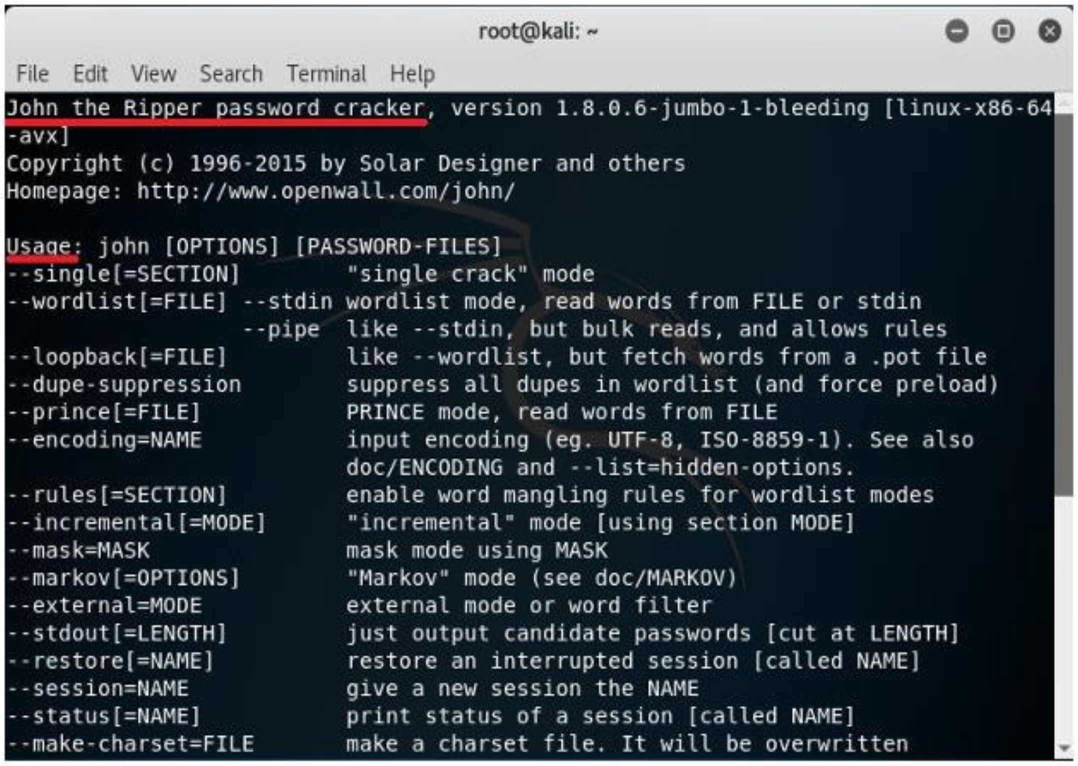
The password in plaintext from hash can be recovered with John-the-ripper tool with the following steps:

Step 1: Open Kali Linux operating system

Step 2: In Kali Linux operating system, open John-the-ripper tool. Go to Applications-> Password attacks-> john



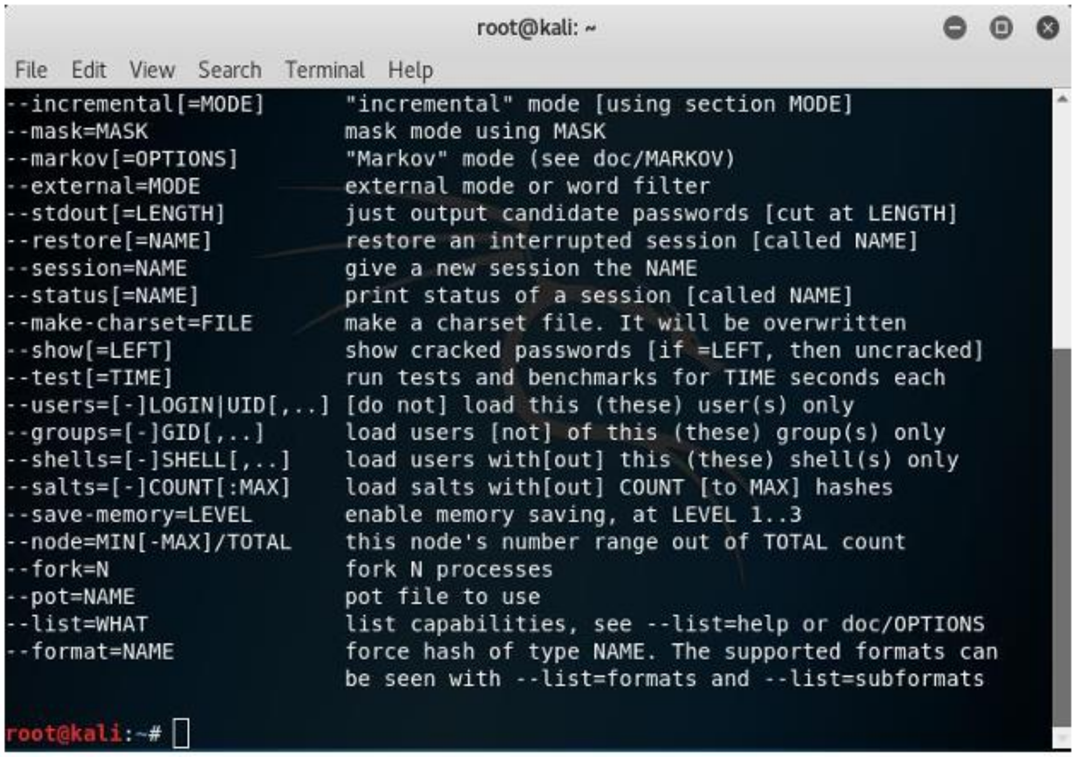
Step 3: A terminal with usage of John-the-ripper tool will open



root@kali: ~

File Edit View Search Terminal Help

```
John the Ripper password cracker, version 1.8.0.6-jumbo-1-bleeding [linux-x86-64
-avx]
Copyright (c) 1996-2015 by Solar Designer and others
Homepage: http://www.openwall.com/john/

Usage: john [OPTIONS] [PASSWORD-FILES]
--single[=SECTION]         "single crack" mode
--wordlist[=FILE] --stdin  wordlist mode, read words from FILE or stdin
                  --pipe   like --stdin, but bulk reads, and allows rules
--loopback[=FILE]          like --wordlist, but fetch words from a .pot file
--dupe-suppression         suppress all dupes in wordlist (and force preload)
--prince[=FILE]            PRINCE mode, read words from FILE
--encoding=NAME            input encoding (eg. UTF-8, ISO-8859-1). See also
                           doc/ENCODING and --list=hidden-options.
--rules[=SECTION]          enable word mangling rules for wordlist modes
--incremental[=MODE]       "incremental" mode [using section MODE]
--mask=MASK                mask mode using MASK
--markov[=OPTIONS]         "Markov" mode (see doc/MARKOV)
--external=MODE            external mode or word filter
--stdout[=LENGTH]          just output candidate passwords [cut at LENGTH]
--restore[=NAME]           restore an interrupted session [called NAME]
--session=NAME             give a new session the NAME
--status[=NAME]            print status of a session [called NAME]
--make-charset=FILE        make a charset file. It will be overwritten
```

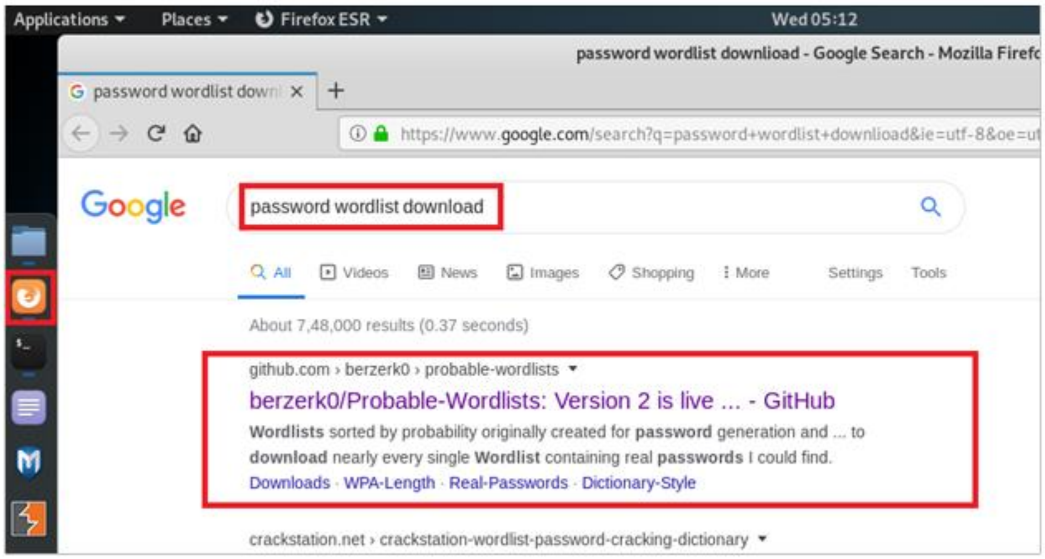


root@kali: ~

File Edit View Search Terminal Help

```
--incremental[=MODE]       "incremental" mode [using section MODE]
--mask=MASK                mask mode using MASK
--markov[=OPTIONS]         "Markov" mode (see doc/MARKOV)
--external=MODE            external mode or word filter
--stdout[=LENGTH]          just output candidate passwords [cut at LENGTH]
--restore[=NAME]           restore an interrupted session [called NAME]
--session=NAME             give a new session the NAME
--status[=NAME]            print status of a session [called NAME]
--make-charset=FILE        make a charset file. It will be overwritten
--show[=LEFT]              show cracked passwords [if =LEFT, then uncracked]
--test[=TIME]              run tests and benchmarks for TIME seconds each
--users=[-]LOGIN|UID[,..]  [do not] load this (these) user(s) only
--groups=[-]GID[,..]       load users [not] of this (these) group(s) only
--shells=[-]SHELL[,..]     load users with[out] this (these) shell(s) only
--salts=[-]COUNT[:MAX]     load salts with[out] COUNT [to MAX] hashes
--save-memory=LEVEL        enable memory saving, at LEVEL 1..3
--node=MIN[-MAX]/TOTAL     this node's number range out of TOTAL count
--fork=N                   fork N processes
--pot=NAME                 pot file to use
--list=WHAT                list capabilities, see --list=help or doc/OPTIONS
--format=NAME              force hash of type NAME. The supported formats can
                           be seen with --list=formats and --list=subformats

root@kali:~# 
```

Step 4: Search the password wordlist by browsing Google search engine. Open the GitHub website and download the ZIP file


Applications
Places
Firefox ESR
Wed 05:12
password wordlist download - Google Search - Mozilla Firefc
password wordlist downl
https://www.google.com/search?q=password+wordlist+downlload&ie=utf-8&oe=ut
Google
password wordlist download
All
Videos
News
Images
Shopping
More
Settings
Tools

About 7,48,000 results (0.37 seconds)

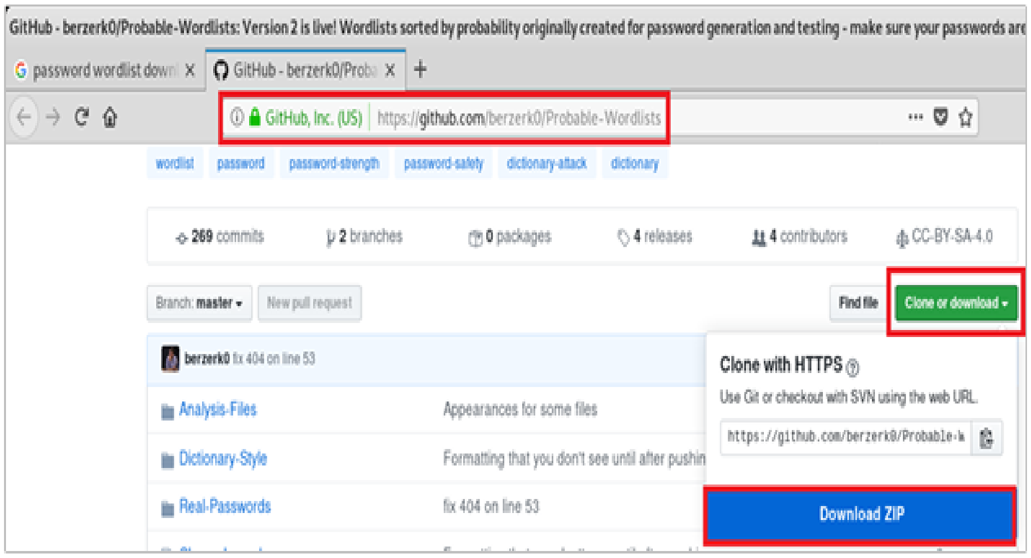
github.com › berzerk0 › probable-wordlists

berzerk0/Probable-Wordlists: Version 2 is live ... - GitHub

Wordlists sorted by probability originally created for **password** generation and ... to **download** nearly every single **Wordlist** containing real **passwords** I could find.

Downloads · WPA-Length · Real-Passwords · Dictionary-Style

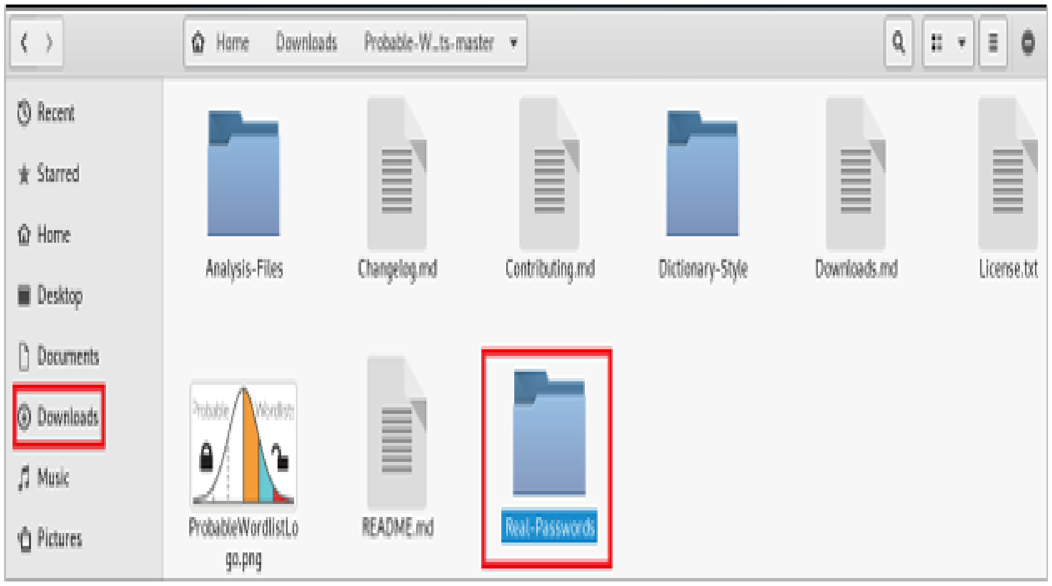
crackstation.net › crackstation-wordlist-password-cracking-dictionary

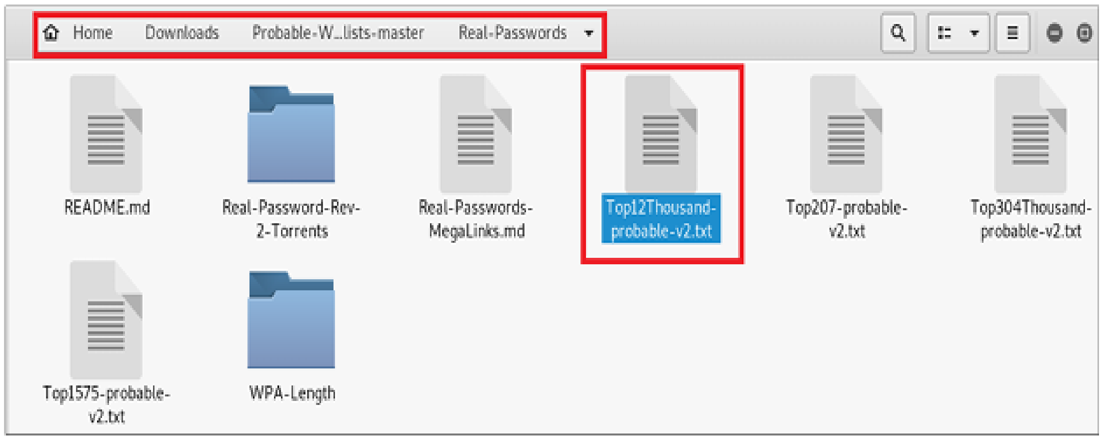

GitHub - berzerk0/Probable-Wordlists: Version 2 is live! Wordlists sorted by probability originally created for password generation and testing - make sure your passwords are
password wordlist downl
GitHub - berzerk0/Proba
GitHub, Inc. (US)
https://github.com/berzerk0/Probable-Wordlists
wordlist
password
password-strength
password-safety
dictionary-attack
dictionary
269 commits
2 branches
0 packages
4 releases
4 contributors
CC-BY-SA-4.0
Branch: master
New pull request
Find file
Clone or download
Clone with HTTPS
Use Git or checkout with SVN using the web URL.
https://github.com/berzerk0/Probable-W
Download ZIP

berzerk0 fix 404 on line 53

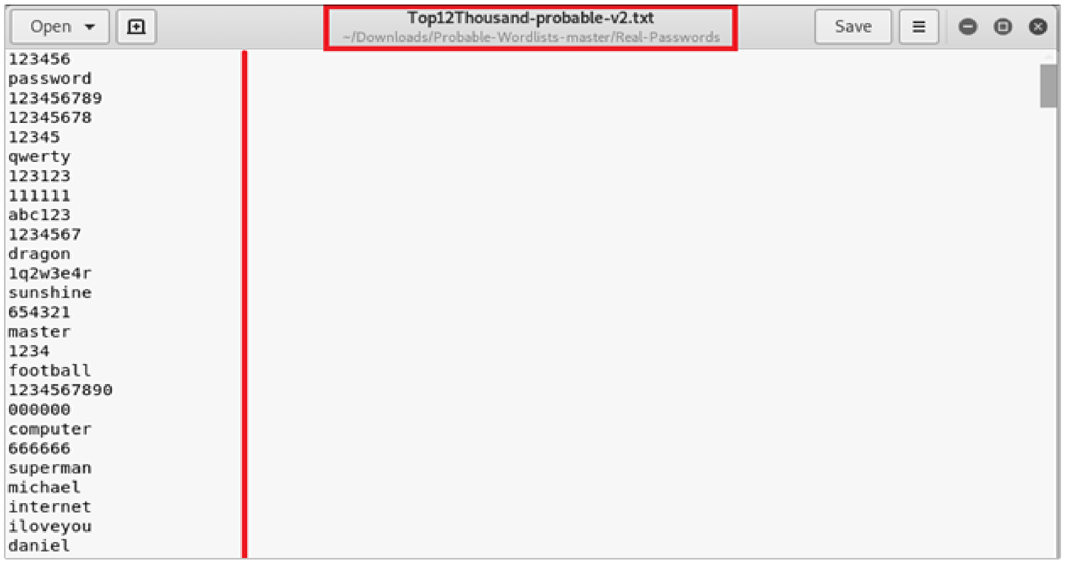
Analysis-Files	Appearances for some files
Dictionary-Style	Formatting that you don't see until after pushin
Real-Passwords	fix 404 on line 53

Step 5: Save and open the downloaded file. Open the “Real-Passwords” folder to see the passwords wordlist.

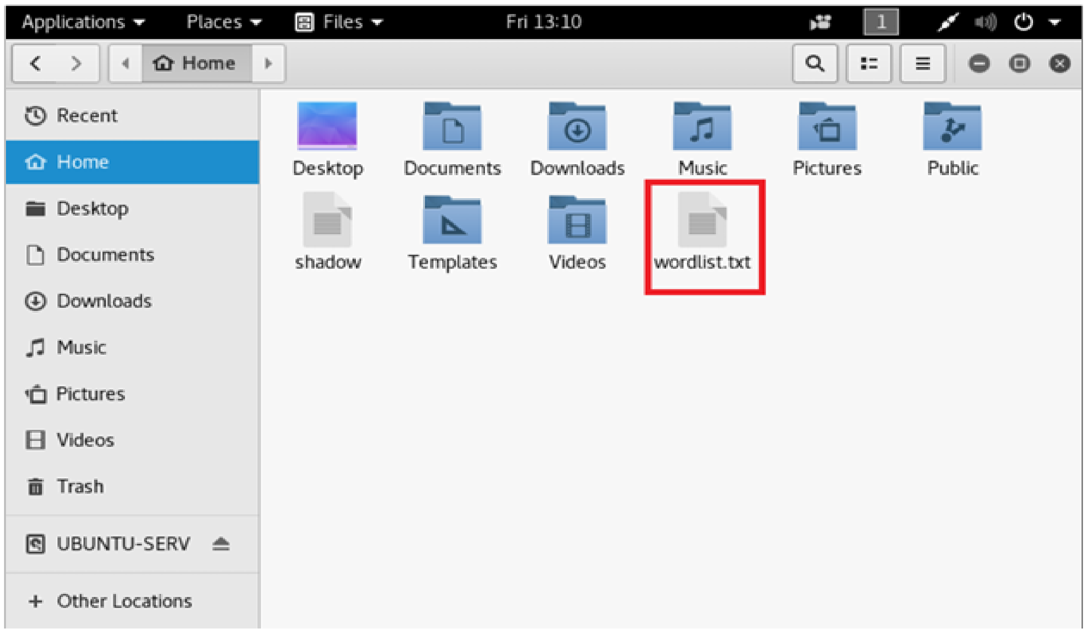



Home
Downloads
Probable-W...lists-master
Real-Passwords
README.md
Real-Password-Rev-2-Torrents
Real-Passwords-MegaLinks.md
Top12Thousand-probable-v2.txt
Top207-probable-v2.txt
Top304Thousand-probable-v2.txt
Top1575-probable-v2.txt
WPA-Length

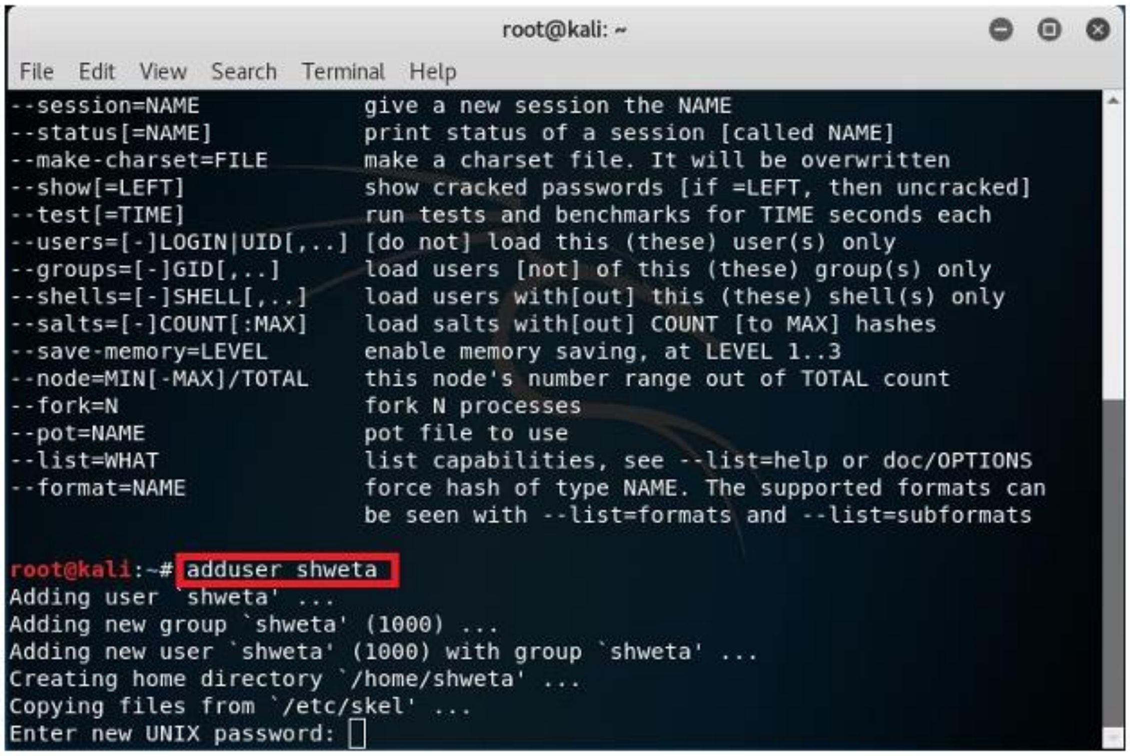
Step 6: Open any password wordlist (e.g., Top12Thousand probable-v2.txt file), Copy this file in Home directory and rename as "wordlist.txt".


Open
Top12Thousand-probable-v2.txt
~/Downloads/Probable-Wordlists-master/Real-Passwords
Save

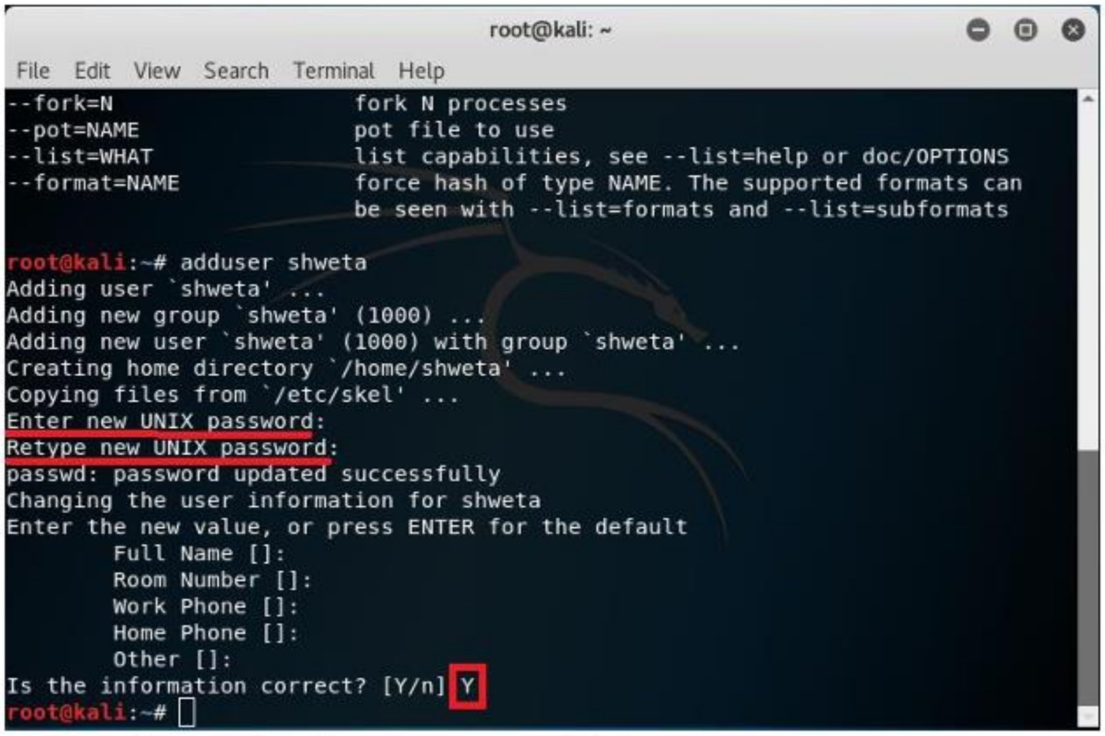
```
123456
password
123456789
12345678
12345
qwerty
123123
111111
abc123
1234567
dragon
1q2w3e4r
sunshine
654321
master
1234
football
1234567890
000000
computer
666666
superman
michael
internet
iloveyou
daniel
```



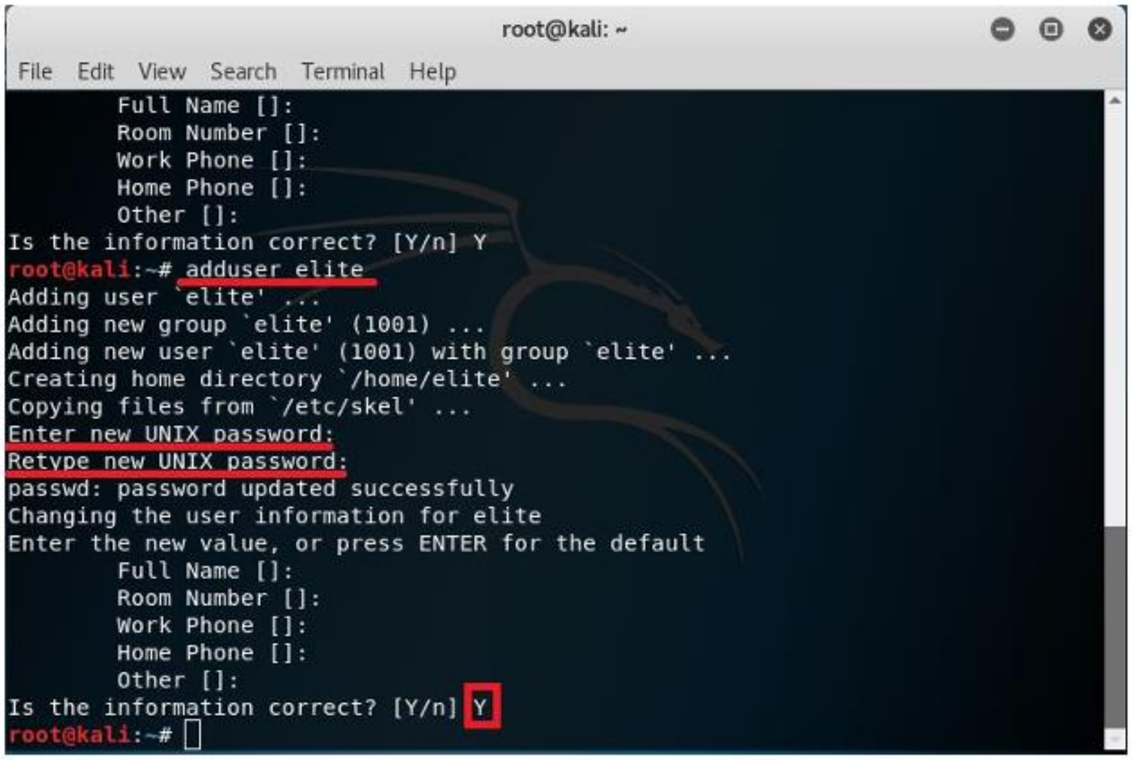
Step 7: Add new users in kali Linux operating system. Set a password and press 'Y' while creating new users.



```
--session=NAME             give a new session the NAME
--status[=NAME]            print status of a session [called NAME]
--make-charset=FILE        make a charset file. It will be overwritten
--show[=LEFT]              show cracked passwords [if =LEFT, then uncracked]
--test[=TIME]              run tests and benchmarks for TIME seconds each
--users=[-]LOGIN|UID[,..] [do not] load this (these) user(s) only
--groups=[-]GID[,..]       load users [not] of this (these) group(s) only
--shells=[-]SHELL[,..]     load users with[out] this (these) shell(s) only
--salts=[-]COUNT[:MAX]     load salts with[out] COUNT [to MAX] hashes
--save-memory=LEVEL        enable memory saving, at LEVEL 1..3
--node=MIN[-MAX]/TOTAL     this node's number range out of TOTAL count
--fork=N                   fork N processes
--pot=NAME                 pot file to use
--list=WHAT                list capabilities, see --list=help or doc/OPTIONS
--format=NAME              force hash of type NAME. The supported formats can
                           be seen with --list=formats and --list=subformats

root@kali:~# adduser shweta
Adding user `shweta' ...
Adding new group `shweta' (1000) ...
Adding new user `shweta' (1000) with group `shweta' ...
Creating home directory `/home/shweta' ...
Copying files from `/etc/skel' ...
Enter new UNIX password:
```

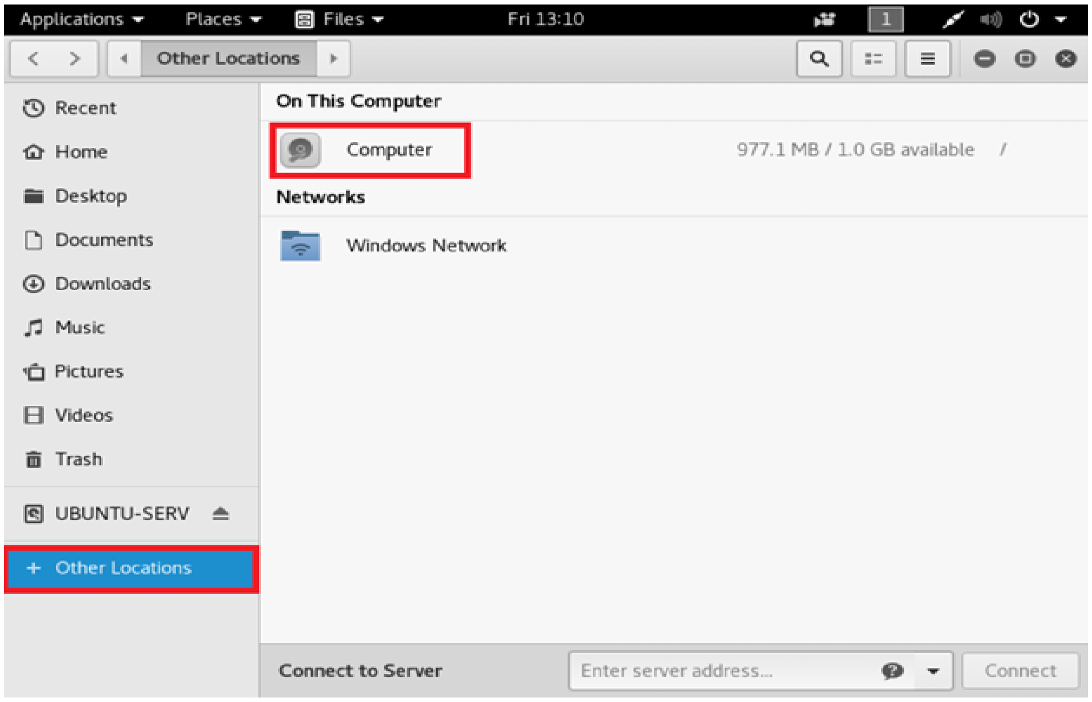


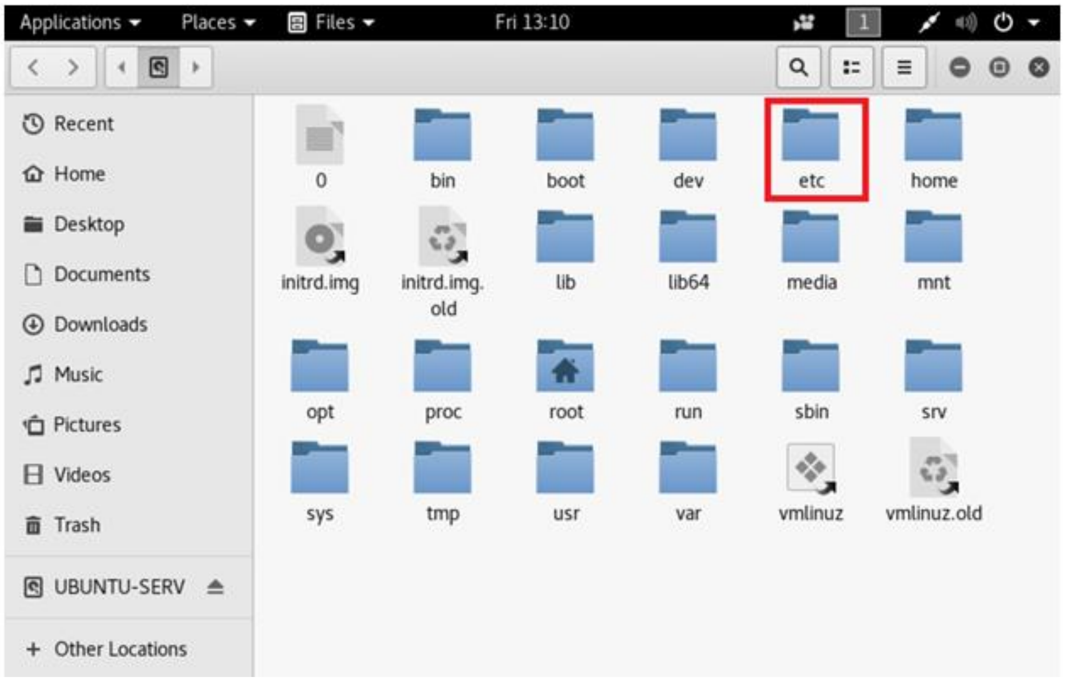
```
--fork=N                   fork N processes
--pot=NAME                 pot file to use
--list=WHAT                list capabilities, see --list=help or doc/OPTIONS
--format=NAME              force hash of type NAME. The supported formats can
                           be seen with --list=formats and --list=subformats

root@kali:~# adduser shweta
Adding user `shweta' ...
Adding new group `shweta' (1000) ...
Adding new user `shweta' (1000) with group `shweta' ...
Creating home directory `/home/shweta' ...
Copying files from `/etc/skel' ...
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
Changing the user information for shweta
Enter the new value, or press ENTER for the default
        Full Name []:
        Room Number []:
        Work Phone []:
        Home Phone []:
        Other []:
Is the information correct? [Y/n] Y
root@kali:~#
```

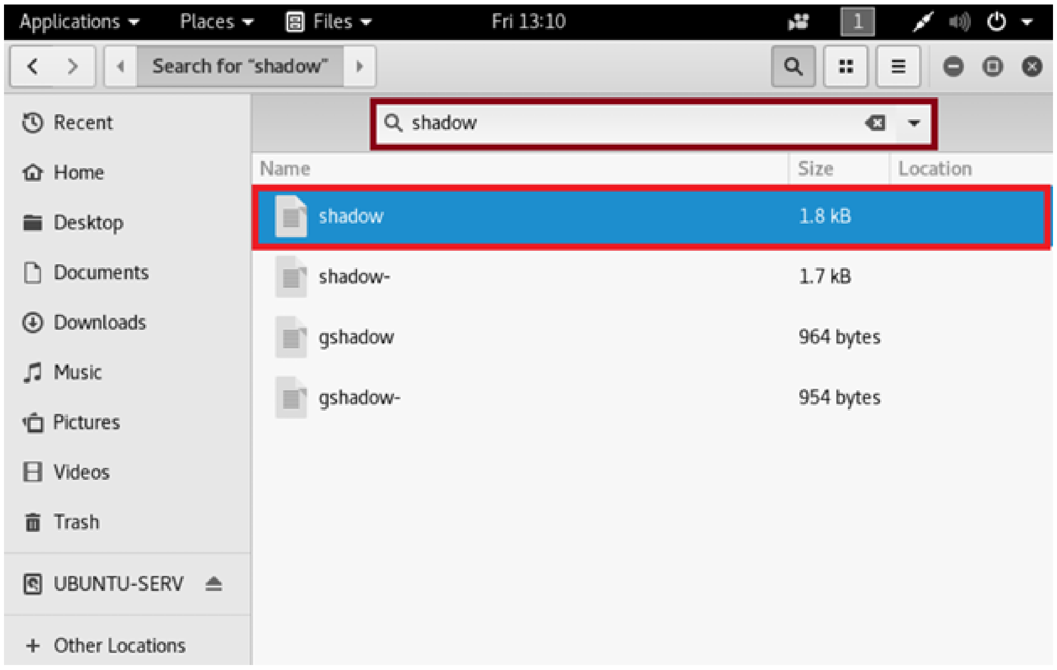


```
        Full Name []:
        Room Number []:
        Work Phone []:
        Home Phone []:
        Other []:
Is the information correct? [Y/n] Y
root@kali:~# adduser elite
Adding user `elite' ...
Adding new group `elite' (1001) ...
Adding new user `elite' (1001) with group `elite' ...
Creating home directory `/home/elite' ...
Copying files from `/etc/skel' ...
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
Changing the user information for elite
Enter the new value, or press ENTER for the default
        Full Name []:
        Room Number []:
        Work Phone []:
        Home Phone []:
        Other []:
Is the information correct? [Y/n] Y
root@kali:~#
```

Step 8: Go to Other Locations->Computer->etc folder to find the shadow file.

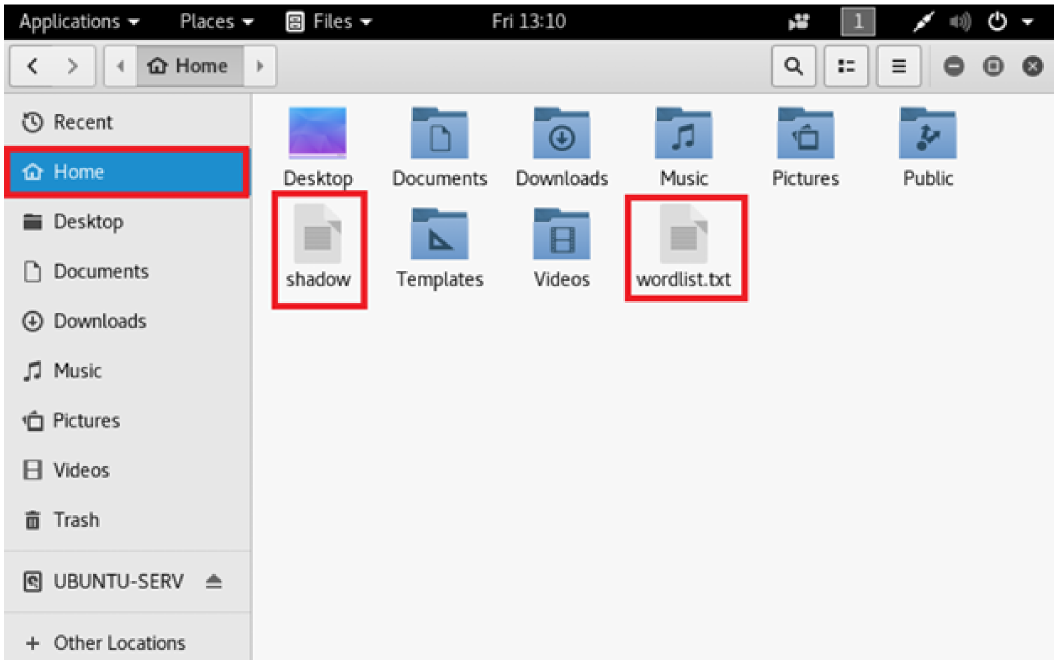

Applications
Places
Files
Fri 13:10
Other Locations
Recent
Home
Desktop
Documents
Downloads
Music
Pictures
Videos
Trash
UBUNTU-SERV
Other Locations
On This Computer
Computer
977.1 MB / 1.0 GB available /
Networks
Windows Network
Connect to Server
Enter server address...
Connect


Applications
Places
Files
Fri 13:10
Recent
Home
Desktop
Documents
Downloads
Music
Pictures
Videos
Trash
UBUNTU-SERV
Other Locations
0
bin
boot
dev
etc
home
initrd.img
initrd.img.old
lib
lib64
media
mnt
opt
proc
root
run
sbin
srv
sys
tmp
usr
var
vmlinuz
vmlinuz.old

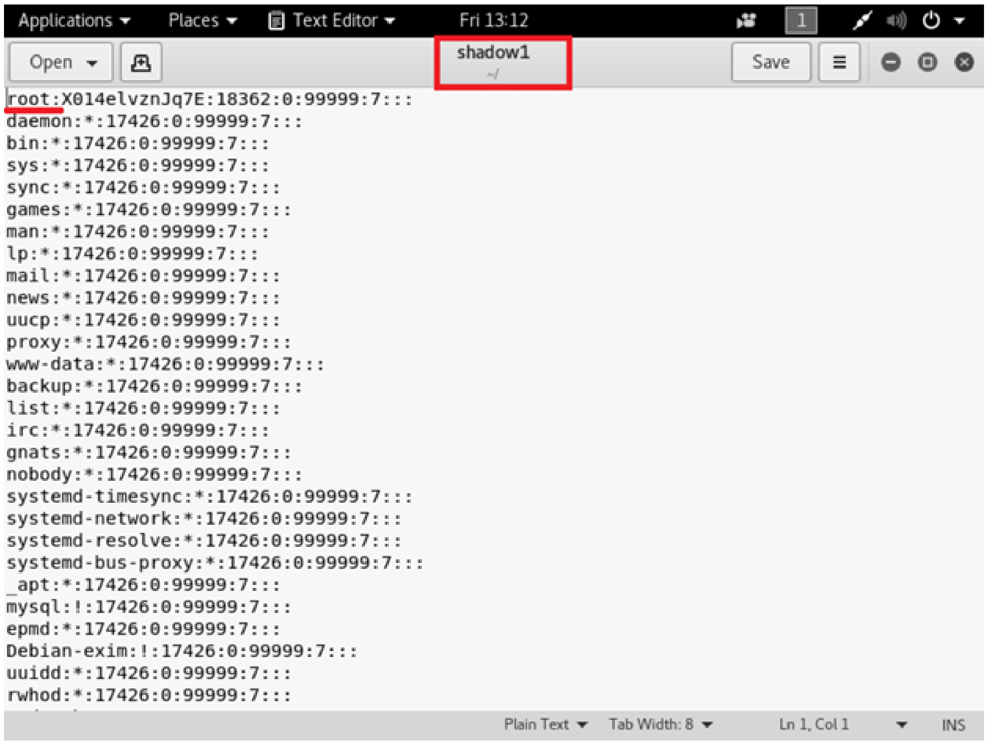


Name	Size	Location
shadow	1.8 kB	
shadow-	1.7 kB	
gshadow	964 bytes	
gshadow-	954 bytes	

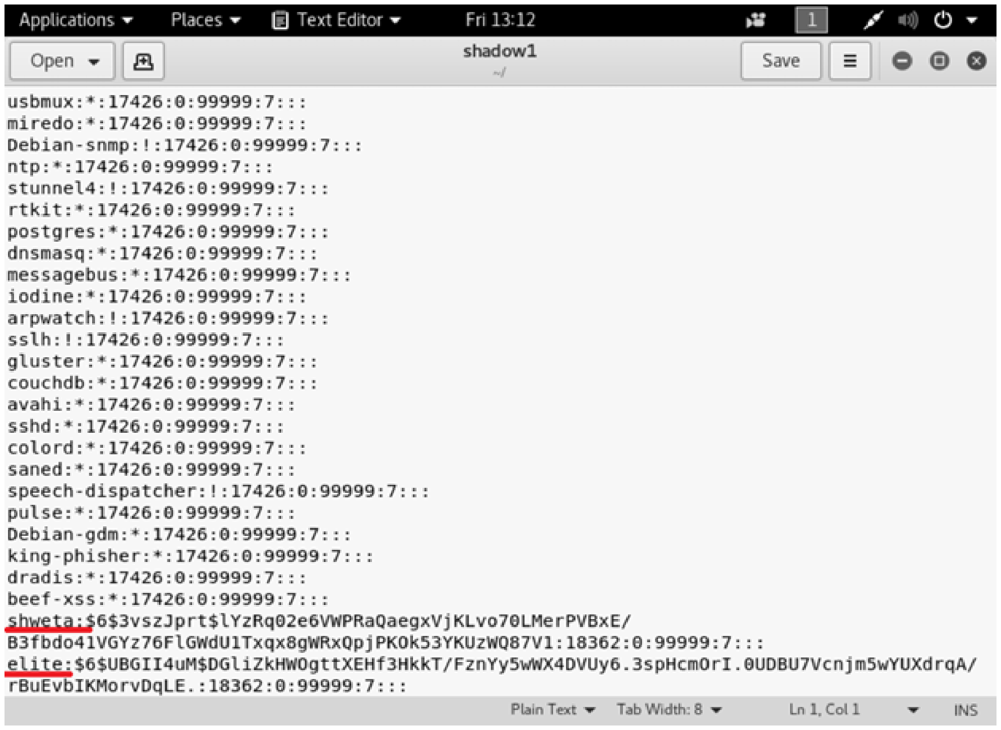
Step 9: Copy the shadow file and paste in Home directory.



Step 10: Rename the shadow file as shadow1 and open the file to find the usernames and password in the form of hash values.

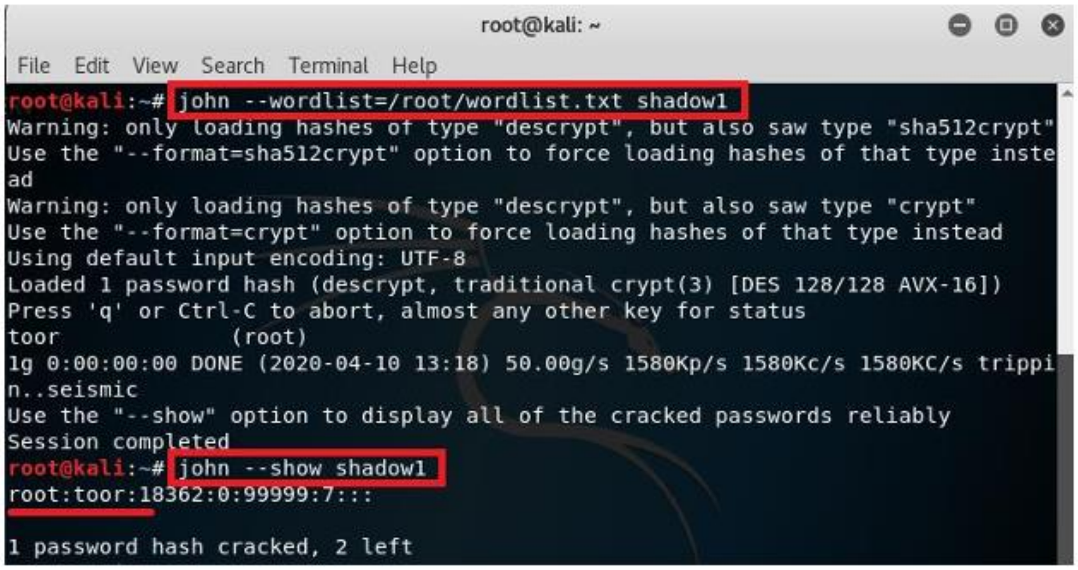


```
root:X014elvznJq7E:18362:0:99999:7:::
daemon:*:17426:0:99999:7:::
bin:*:17426:0:99999:7:::
sys:*:17426:0:99999:7:::
sync:*:17426:0:99999:7:::
games:*:17426:0:99999:7:::
man:*:17426:0:99999:7:::
lp:*:17426:0:99999:7:::
mail:*:17426:0:99999:7:::
news:*:17426:0:99999:7:::
uucp:*:17426:0:99999:7:::
proxy:*:17426:0:99999:7:::
www-data:*:17426:0:99999:7:::
backup:*:17426:0:99999:7:::
list:*:17426:0:99999:7:::
irc:*:17426:0:99999:7:::
gnats:*:17426:0:99999:7:::
nobody:*:17426:0:99999:7:::
systemd-timesync:*:17426:0:99999:7:::
systemd-network:*:17426:0:99999:7:::
systemd-resolve:*:17426:0:99999:7:::
systemd-bus-proxy:*:17426:0:99999:7:::
_apt:*:17426:0:99999:7:::
mysql:!:17426:0:99999:7:::
epmd:*:17426:0:99999:7:::
Debian-exim:!:17426:0:99999:7:::
uuidd:*:17426:0:99999:7:::
rwhod:*:17426:0:99999:7:::
```



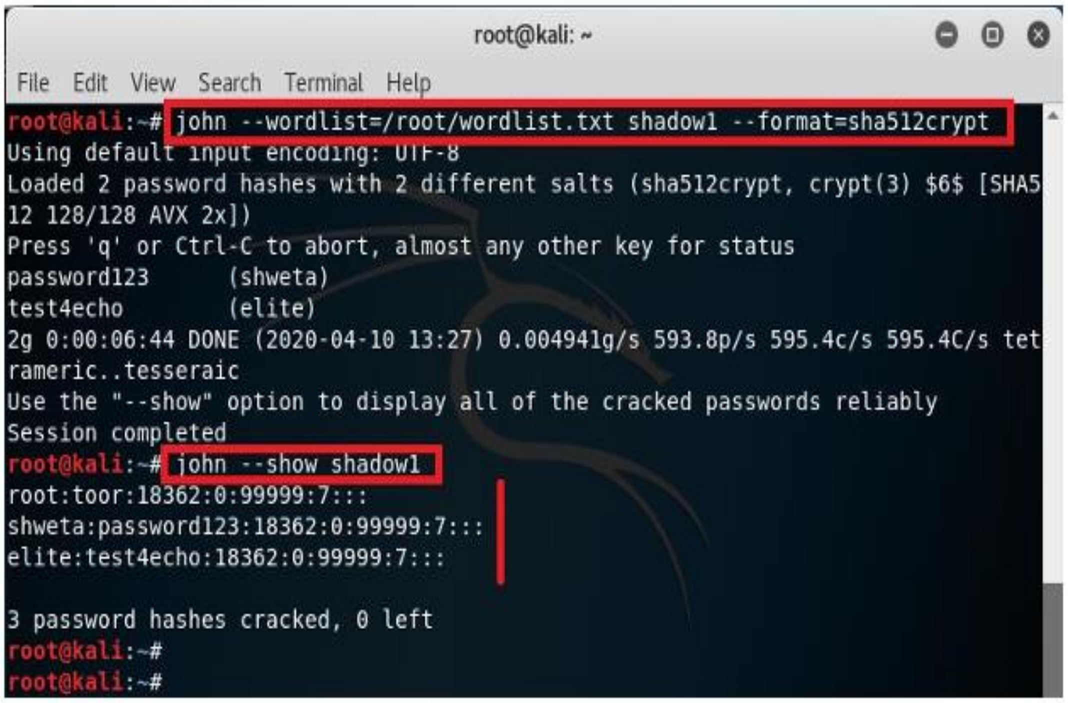
```
usbmux:*:17426:0:99999:7:::
miredo:*:17426:0:99999:7:::
Debian-snmp:!:17426:0:99999:7:::
ntp:*:17426:0:99999:7:::
stunnel4:!:17426:0:99999:7:::
rtkit:*:17426:0:99999:7:::
postgres:*:17426:0:99999:7:::
dnsmasq:*:17426:0:99999:7:::
messagebus:*:17426:0:99999:7:::
iodine:*:17426:0:99999:7:::
arpwatch:!:17426:0:99999:7:::
sslh:!:17426:0:99999:7:::
gluster:*:17426:0:99999:7:::
couchdb:*:17426:0:99999:7:::
avahi:*:17426:0:99999:7:::
sshd:*:17426:0:99999:7:::
colord:*:17426:0:99999:7:::
saned:*:17426:0:99999:7:::
speech-dispatcher:!:17426:0:99999:7:::
pulse:*:17426:0:99999:7:::
Debian-gdm:*:17426:0:99999:7:::
king-phisher:*:17426:0:99999:7:::
dradis:*:17426:0:99999:7:::
beef-xss:*:17426:0:99999:7:::
shweta:$6$3vszJprt$lYzRq02e6VWPRaQaegxVjKLvo70LMerPVBxE/
B3fbdo41VGYz76FlGWdU1Txqx8gWRxQpjPKOk53YKUzWQ87V1:18362:0:99999:7:::
elite:$6$UBGII4uM$DGliZkHWOgttXEHf3HkkT/FznYy5wWX4DVUy6.3spHcmOrI.0UDBU7Vcnjm5wYUXdrqA/
rBuEvbIKMorvDqLE.:18362:0:99999:7:::
```

Step 11: Write the command "john --wordlist=/root/ wordlist.txt" to recover the hash of root and "john --show shadow1" to display the passwords in plaintext.



```
root@kali:~# john --wordlist=/root/wordlist.txt shadow1
Warning: only loading hashes of type "descrypt", but also saw type "sha512crypt"
Use the "--format=sha512crypt" option to force loading hashes of that type inste
ad
Warning: only loading hashes of type "descrypt", but also saw type "crypt"
Use the "--format=crypt" option to force loading hashes of that type instead
Using default input encoding: UTF-8
Loaded 1 password hash (descrypt, traditional crypt(3) [DES 128/128 AVX-16])
Press 'q' or Ctrl-C to abort, almost any other key for status
toor             (root)
1g 0:00:00:00 DONE (2020-04-10 13:18) 50.00g/s 1580Kp/s 1580Kc/s 1580KC/s trippi
n..seismic
Use the "--show" option to display all of the cracked passwords reliably
Session completed
root@kali:~# john --show shadow1
root:toor:18362:0:99999:7:::

1 password hash cracked, 2 left
```

Step 12: Write the command "john --wordlist= /root/wordlist.txt --format=sha512crypt" to recover the hash of other users and "john --show shadow1" to display the passwords in plaintext. The passwords in plaintext are displayed and highlighted in red rectangular box.



```
root@kali:~# john --wordlist=/root/wordlist.txt shadow1 --format=sha512crypt
Using default input encoding: UTF-8
Loaded 2 password hashes with 2 different salts (sha512crypt, crypt(3) $6$ [SHA5
12 128/128 AVX 2x])
Press 'q' or Ctrl-C to abort, almost any other key for status
password123      (shweta)
test4echo        (elite)
2g 0:00:06:44 DONE (2020-04-10 13:27) 0.004941g/s 593.8p/s 595.4c/s 595.4C/s tet
rameric..tesseraic
Use the "--show" option to display all of the cracked passwords reliably
Session completed
root@kali:~# john --show shadow1
root:toor:18362:0:99999:7:::
shweta:password123:18362:0:99999:7:::
elite:test4echo:18362:0:99999:7:::

3 password hashes cracked, 0 left
root@kali:~#
root@kali:~#
```

IX. Precautions

1. Use password recovery tools only on authorized systems.
2. Do not share recovered passwords.
3. Ensure system backup before applying password recovery.
4. Avoid weak passwords to reduce the risk of unauthorized access.

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Difference between single-level and multi-level authentication.
2. Steps to recover passwords using John the Ripper.
3. Describe the risks of weak passwords.
4. Why should password recovery be restricted to authorized administrators?

Space for Answer

……………………………………………………………………………………………..…..

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XI. Exercise

1. Configure password complexity policy in Windows/Linux.
2. Use a different open-source tool (e.g., Ophcrack) for password recovery.
3. Compare recovery time between dictionary attack and brute force attack.

XII. References / Suggestions for further reading

1. Stallings, W. & Brown, L., 2014. Computer Security: Principles and Practice. Pearson. Publisher link
2. John the Ripper Documentation: https://www.openwall.com/john
3. NPTEL: Introduction to Information Security.

XIII. Assessment schemes

Performance Indicators		Weightage
Process related (15 Marks)		**60 %**
1	Following correct authentication setup procedure	20 %
2	Recovering password using open-source tool	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Quality of output (System secured & password recovered)	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			Dated Signature of Teacher
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 03: i. Grant security to file, folder or application using access permissions and verify it
ii. Grant access permission while sharing file and folder

I. Practical Significance

This practical demonstrates how to secure files, folders, and applications by assigning proper access permissions. Access control ensures that only authorized users can read, modify, or execute resources. Proper sharing and permission management prevents unauthorized access, accidental modifications, and data breaches in enterprise and multi-user environments.

II. Industry / Employer Expected Outcome

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO2: Apply multi-factor user authentication and access control.

IV. Laboratory Learning Outcome (LLO)

LLO 3.1: Grant read, write, and execute permission on file and folder.

V. Relevant Affective domain related Outcomes(s)

- Responsibility: Maintaining integrity of organizational data.
- Attention to Detail: Carefully assigning and verifying permissions.
- Ethical Awareness: Avoiding misuse of administrative rights.

VI. Theoretical Background

Access control mechanisms in operating systems allow administrators to define which users or groups can access specific resources. In both Windows and Linux, permissions are fundamental to maintaining data confidentiality, integrity, and availability.

In Windows, every file and folder has its own set of permissions defined through Access Control Lists (ACLs). These permissions can be inherited from parent folders, typically involving users such as SYSTEM, the logged-in account, and the Administrators group. Windows supports six primary permission types: Full Control, Modify, Read & Execute, List Folder Contents, Read, and Write. Together, NTFS permissions and sharing permissions regulate both local and network access.

In Linux, file permissions follow a similar principle but are represented using symbolic notation (r, w, x for read, write, and execute) or octal values (e.g., 755). These permissions apply to three categories of users: owner, group, and others.

By combining local permissions with shared folder access control, operating systems ensure secure collaboration while preventing unauthorized access and safeguarding system resources.

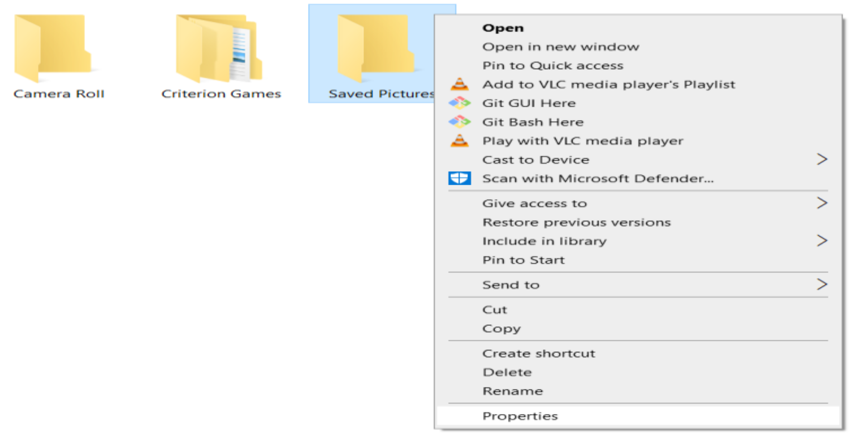
VII. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows XP / 7 onwards / LINUX V 5.0 or latest		
3	Tools / Software Required	File Explorer (Windows),		

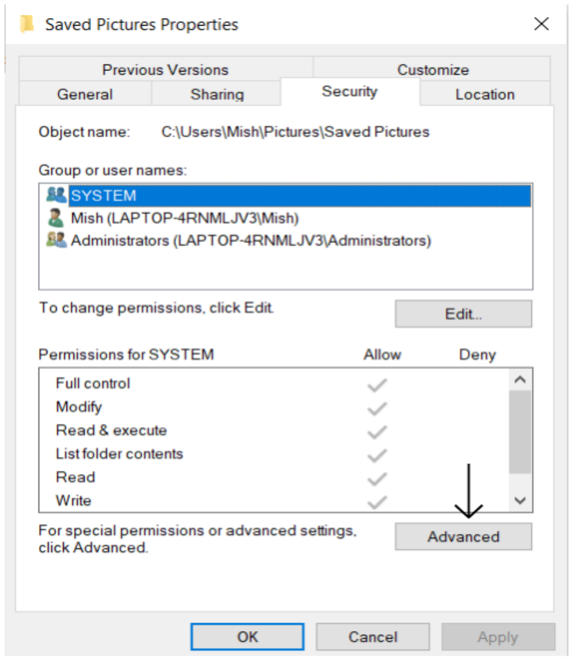
VIII. Procedure

Apply security to file folder

1. Right click the folder or file and click “Properties” in the context menu.



2. Go to the **Security** tab and click on **Advanced**, located at the bottom-right corner of your screen.



Object name: C:\Users\Mish\Pictures\Saved Pictures

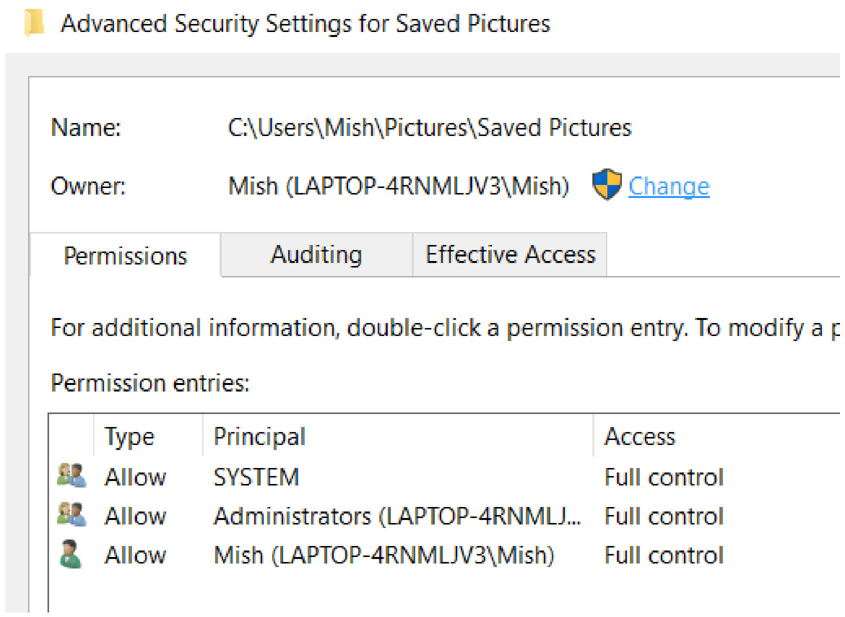
Group or user names:
SYSTEM
Mish (LAPTOP-4RNMLJV3\Mish)
Administrators (LAPTOP-4RNMLJV3\Administrators)

To change permissions, click Edit.

Permissions for SYSTEM	Allow	Deny
Full control	✓	
Modify	✓	
Read & execute	✓	
List folder contents	✓	
Read	✓	
Write	✓	

For special permissions or advanced settings, click Advanced.

3. Click on **Change**.



Advanced Security Settings for Saved Pictures

Name: C:\Users\Mish\Pictures\Saved Pictures

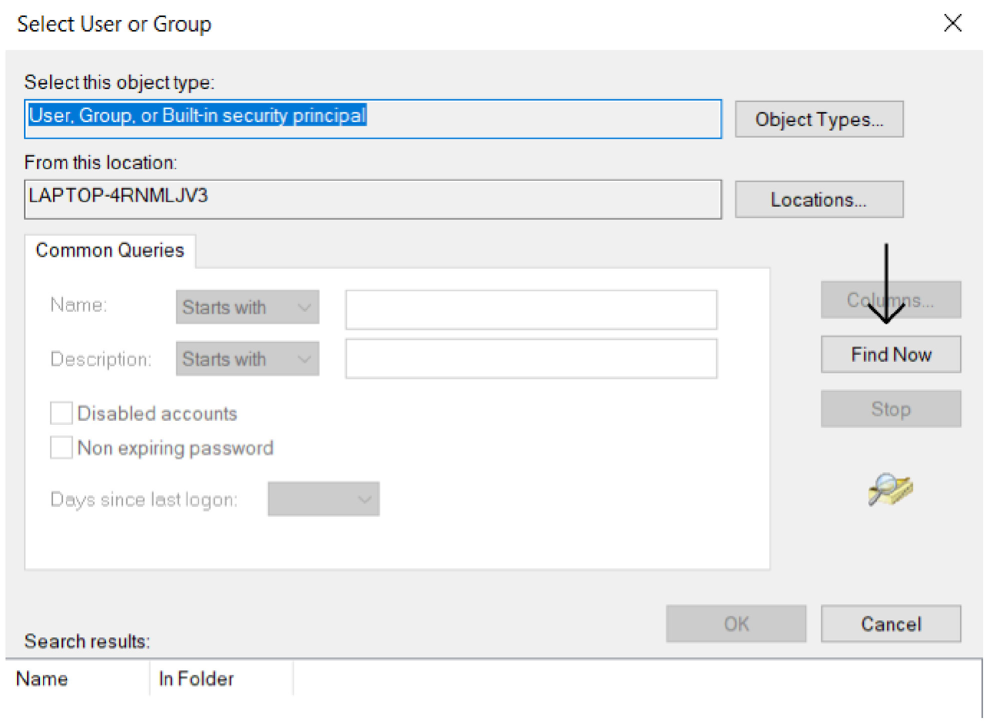
Owner: Mish (LAPTOP-4RNMLJV3\Mish) Change

For additional information, double-click a permission entry. To modify a p

Permission entries:

Type	Principal	Access
Allow	SYSTEM	Full control
Allow	Administrators (LAPTOP-4RNMLJ...	Full control
Allow	Mish (LAPTOP-4RNMLJV3\Mish)	Full control

4. Click on **Find Now**.

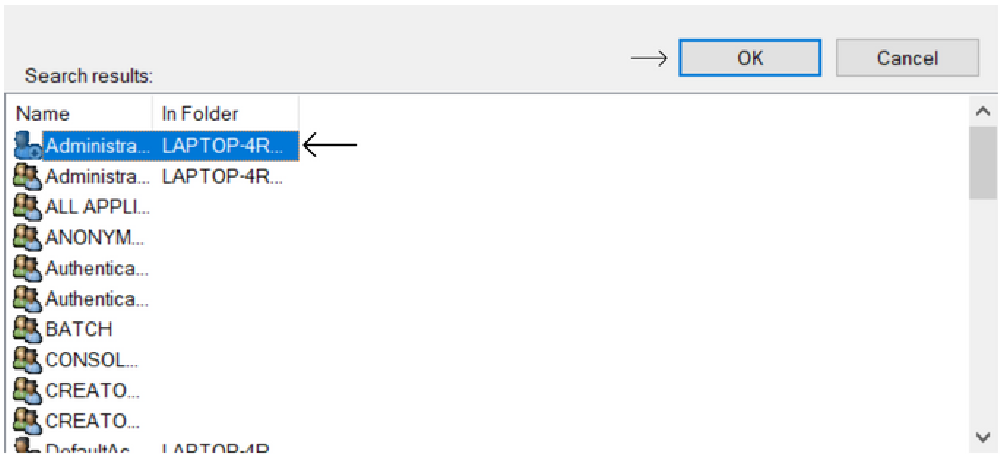


Select User or Group

Select this object type: User, Group, or Built-in security principal

From this location: LAPTOP-4RNMLJV3

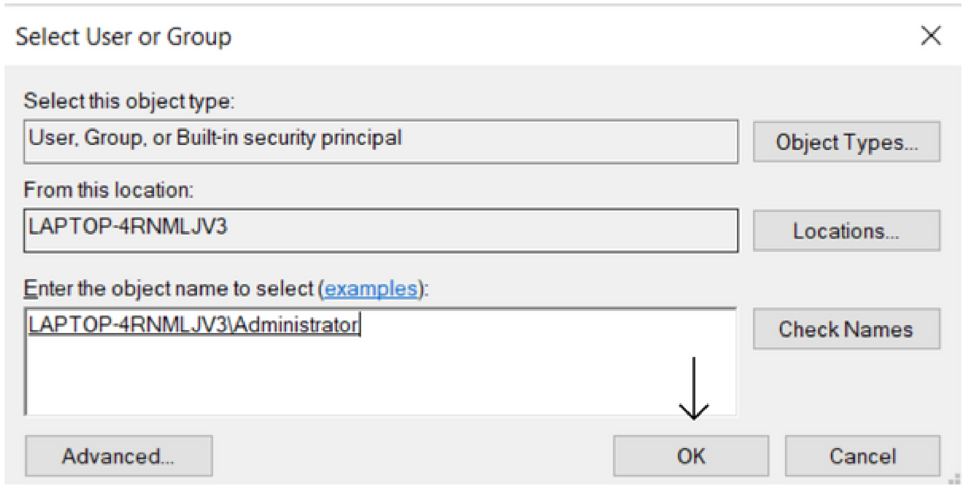
5. Select your username and hit **OK**.



Search results:

Name	In Folder
Administra...	LAPTOP-4R...
Administra...	LAPTOP-4R...
ALL APPLI...	
ANONYM...	
Authentica...	
Authentica...	
BATCH	
CONSOL...	
CREATO...	
CREATO...	
DefaultAc...	LAPTOP-4R...

6. Click **OK**.



Select User or Group

Select this object type:
User, Group, or Built-in security principal

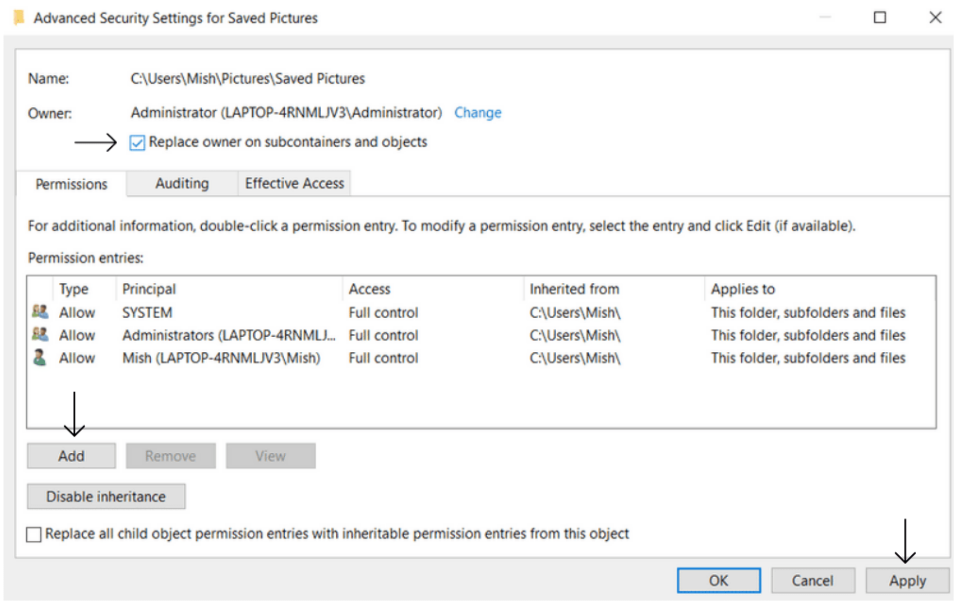
From this location:
LAPTOP-4RNMLJV3

Enter the object name to select (examples):
LAPTOP-4RNMLJV3\Administrator

- Check the box that says **Replace owner on sub containers and objects** and click on **Apply**.

Now, you need to repeat **steps 1-3** and reach this page again.

- This time around, click on the **Add** button on your screen.



Advanced Security Settings for Saved Pictures

Name: C:\Users\Mish\Pictures\Saved Pictures

Owner: Administrator (LAPTOP-4RNMLJV3\Administrator) Change

☑ Replace owner on subcontainers and objects

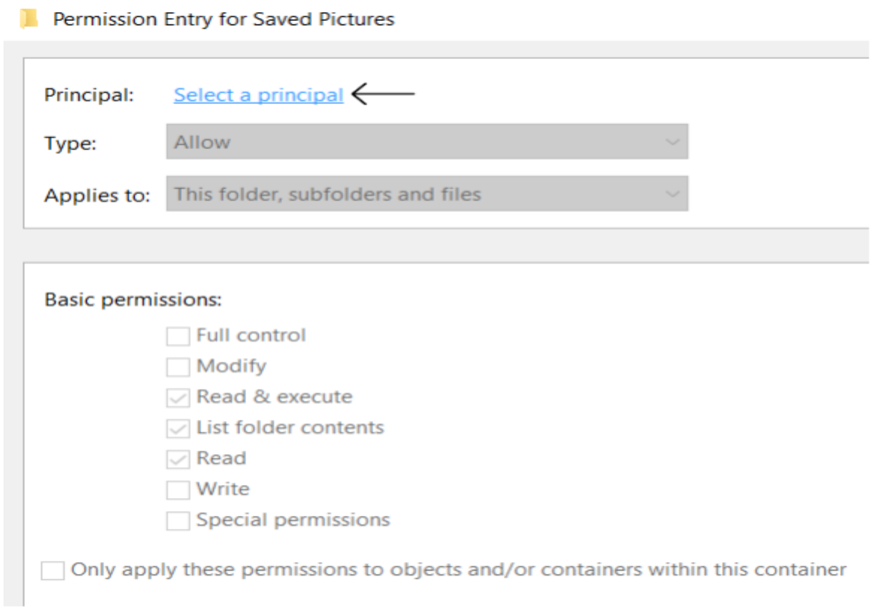
For additional information, double-click a permission entry. To modify a permission entry, select the entry and click Edit (if available).

Permission entries:

Type	Principal	Access	Inherited from	Applies to
Allow	SYSTEM	Full control	C:\Users\Mish\	This folder, subfolders and files
Allow	Administrators (LAPTOP-4RNMLJ...	Full control	C:\Users\Mish\	This folder, subfolders and files
Allow	Mish (LAPTOP-4RNMLJV3\Mish)	Full control	C:\Users\Mish\	This folder, subfolders and files

☐ Replace all child object permission entries with inheritable permission entries from this object

7. Click on **Select a principal**.



Permission Entry for Saved Pictures

Principal: Select a principal

Type: Allow

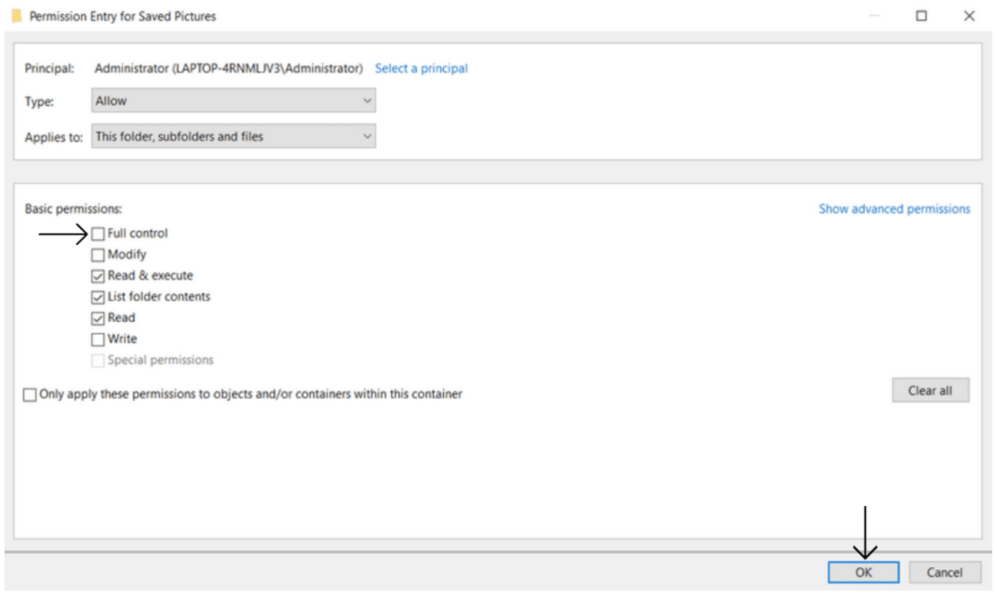
Applies to: This folder, subfolders and files

Basic permissions:

- [ ] Full control
- [ ] Modify
- [x] Read & execute
- [x] List folder contents
- [x] Read
- [ ] Write
- [ ] Special permissions

[ ] Only apply these permissions to objects and/or containers within this container

8. Check the box that says **Full control**. Then, hit **OK**.



Permission Entry for Saved Pictures

Principal: Administrator (LAPTOP-4RNMLJV3\Administrator) Select a principal

Type: Allow

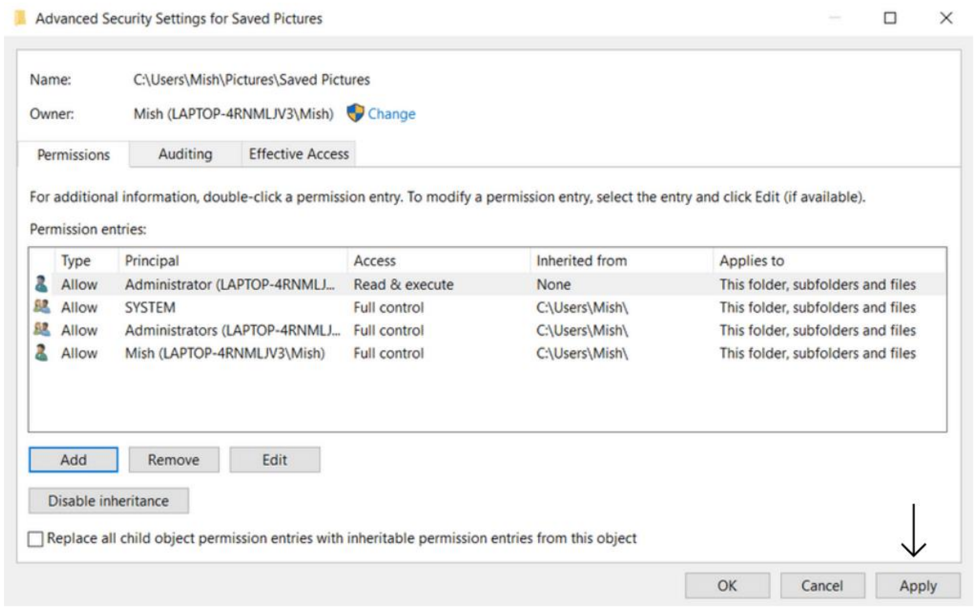
Applies to: This folder, subfolders and files

Basic permissions:

- [ ] Full control
- [ ] Modify
- [x] Read & execute
- [x] List folder contents
- [x] Read
- [ ] Write
- [ ] Special permissions

[ ] Only apply these permissions to objects and/or containers within this container

9. Click on **Apply**.


Advanced Security Settings for Saved Pictures
Name: C:\Users\Mish\Pictures\Saved Pictures
Owner: Mish (LAPTOP-4RNMLJV3\Mish) Change
Permissions
Auditing
Effective Access
For additional information, double-click a permission entry. To modify a permission entry, select the entry and click Edit (if available).
Permission entries:

Type	Principal	Access	Inherited from	Applies to
Allow	Administrator (LAPTOP-4RNMLJ...	Read & execute	None	This folder, subfolders and files
Allow	SYSTEM	Full control	C:\Users\Mish\	This folder, subfolders and files
Allow	Administrators (LAPTOP-4RNMLJ...	Full control	C:\Users\Mish\	This folder, subfolders and files
Allow	Mish (LAPTOP-4RNMLJV3\Mish)	Full control	C:\Users\Mish\	This folder, subfolders and files

Add
Remove
Edit
Disable inheritance
Replace all child object permission entries with inheritable permission entries from this object
OK
Cancel
Apply

Procedure of Folder sharing:

Step 1: Select the Folder or File

Click the folder you want to share.

If you want to share a subfolder or a file instead, open its parent folder and then select the subfolder or file.

Step 2: Launch the File Sharing Wizard

Click the **Share** button in the task pane.

Windows Vista launches the **File Sharing Wizard**, which asks you to choose the user accounts you want to share the item with.

Step 3: Add Users

Type the username and click **Add**.

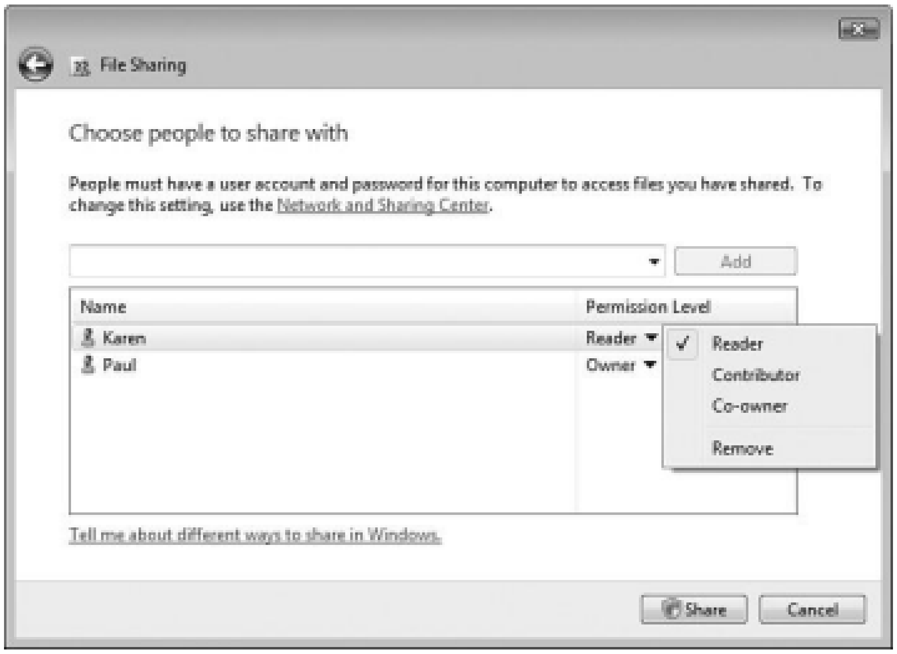
Step 4: Repeat for Additional Users

Repeat step 4 to share the folder or file with other users.

Step 5: Assign Permission Levels

For each user added, assign a permission level by clicking the **downward arrow** and selecting one of the following:

- **Reader** – Default level; user can view and open contents but cannot create, change, or delete anything.
- **Contributor** – User can add new files to the shared folder, and modify or delete only the files they added.
- **Co-owner** – User can create new items, and modify or delete any items in the folder.


File Sharing

Choose people to share with

People must have a user account and password for this computer to access files you have shared. To change this setting, use the Network and Sharing Center.

Name	Permission Level
Karen	Reader
Paul	Owner

IX. Precautions

1. Always assign the minimum required permissions (principle of least privilege).
2. Do not provide full control to unauthorized users.
3. Test permissions after configuration to avoid access errors.
4. Avoid sharing sensitive files without encryption.

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Differentiate between NTFS permissions and Share permissions.
2. How do Linux file permissions differ from Windows file permissions?
3. Why is the principle of least privilege important in access control?

Space for Answer

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XI. Exercise

1. Assign read-only permission to a folder for a user and verify.
2. Share a folder on a Windows system and access it from another system.

XII. References / Suggestions for further reading

1. Stallings, W. & Brown, L., 2014. Computer Security: Principles and Practice. Pearson. Publisher link
2. Administrator Guide Quick Heal Endpoint Security 5.2. Available at: https://dlupdate.quickheal.com/documents/manual/eps5.2_userguide.pdf
3. YouTube, 2020. Firewall Configuration Tutorial. Available at: https://www.youtube.com/watch?v=T9c5ZpT2FV0
4. NPTEL, 2022. Introduction to Information Security. Available at: https://archive.nptel.ac.in/courses/106/106/106106129/
5. Virtual Labs, IIIT Hyderabad, n.d. Cryptography Experiments. Available at: https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html

XIII. Assessment schemes

Performance Indicators		Weightage
Process related (15 Marks)		**60 %**
1	Following correct procedure to assign file/folder/application permissions	20 %
2	Configuring and verifying share permissions on network	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Quality of output (Permissions correctly applied, verified, and secure sharing working)	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			Dated Signature of Teacher
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 04: Write a utility using C/Shell programming to create strong password authentication (Password should be more than 8 characters, and combination of digits, letters and special characters #, %, &, @)

I. Practical Significance

These practical helps students understand the importance of password complexity in authentication. Weak passwords make systems vulnerable to attacks such as brute-force, dictionary attacks, and social engineering. By writing a C program that enforces password policies, learners gain practical knowledge of implementing authentication systems that meet security standards.

II. Industry / Employer Expected Outcome

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO2: Apply multi-factor user authentication and access control.

IV. Laboratory Learning Outcome (LLO)

LLO 4.1**:** Implement password authentication**.**

V. Relevant Affective domain related Outcomes(s)

- Responsibility: Creating secure password authentication utilities.
- Attention to Detail: Enforcing rules correctly.
- Ethical Awareness: Protecting users from weak security practices.

VI. Theoretical Background

A password is a secret string of characters (letters, numbers, or symbols) used to verify the identity of a user and grant access to a computer system, application, or network resource. It is the most widely used method of authentication in operating systems and network security.
Authentication is the process of verifying the identity of a user or system. Password-based authentication is the most common method, but weak passwords compromise security. A **strong password** should:

1. Be more than 8 characters long.
2. Include uppercase and lowercase letters.
3. Include digits.
4. Contain at least one special character (#, %, &, @).

In **C programming**, we can enforce these rules using standard library functions like strlen(), isupper(), islower(), isdigit(), and by scanning for special characters.

VII. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows XP / 7 onwards / LINUX V 5.0 or latest		
3	Tools / Software Required	Turbo C		

VIII. Procedure

Pseudo code to create strong password authentication

```
Step 1: START
Step 2: Initialize variable N to store the desired password length.
Step 3: Seed the random number generator using the current system time (srand(time(NULL))) to
ensure different output each time.
Step 4: Define four character sets:
    - numbers[] = "0123456789"
    - lowercase_letters[] = "abcdefghijklmnoqprstuvwyzx"
    - uppercase_letters[] = "ABCDEFGHIJKLMNOQPRSTUYWVZX"
    - symbols[] = "!@#$^&*?"
Step 5: Initialize a variable randomizer with a random number between 0 and 3.
Step 6: Repeat for each position i from 0 to N-1:
    a. If randomizer == 0, select a random character from lowercase_letters.
    b. Else if randomizer == 1, select a random character from numbers.
    c. Else if randomizer == 2, select a random character from symbols.
    d. Else if randomizer == 3, select a random character from uppercase_letters.
    e. Append the selected character to the password string.
    f. Generate a new randomizer (rand() % 4) for the next iteration.
Step 7: Display the generated password to the user.
Step 8: STOP.
```

IX. Precautions

1. Do not use visible echo for sensitive password input in real systems.
2. Avoid storing plain-text passwords.
3. Use secure hashing (e.g., SHA) in real applications.
4. Test with multiple sample passwords.

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Explain the importance of using a mix of character types in passwords.
2. Describe dictionary attacks.
3. Why should passwords not be stored in plain text?
4. Compare password authentication with biometric authentication.

Space for Answer

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XI. Exercise

1. Enhance the program to allow password re-entry until conditions are met.
2. Implement a password policy that disallows common passwords (like "123456").
3. Modify program to hide input characters while typing.

XII. References / Suggestions for further reading

1. Stallings, W. & Brown, L., 2014. Computer Security: Principles and Practice. Pearson. Publisher link
2. Atul Kahate, *Cryptography and Network Security*. McGraw-Hill.
3. GeeksforGeeks: Password validation programs in C.
4. NPTEL, 2022. Introduction to Information Security. Available at: https://archive.nptel.ac.in/courses/106/106/106106129/
5. Virtual Labs, IIIT Hyderabad, Cryptography Experiments. Available at: https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html

XIII. Assessment schemes

Performance Indicators		**Weightage**
Process related (15 Marks)		**60 %**
1	Writing correct C program structure for password authentication	20 %
2	Implementing password validation rules (length, uppercase, lowercase, digit, special char)	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Quality of output (Password utility works correctly for strong/weak inputs)	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 05: i. Write a C program to implement caesar cipher technique to perform encryption and decryption of text ii. Apply Caesar cipher technique to perform encryption and decryption of text using any open-source tool (Example - Cryptool)

I. Practical Significance

This practical demonstrates how classical substitution ciphers, specifically the Caesar cipher, provide a foundation for understanding modern cryptography. Although insecure by today's standards, it introduces the concepts of encryption, decryption, and key management. By applying the cipher both programmatically and via open-source tools, students gain insight into manual implementation and automated cryptographic utilities.

II. Industry / Employer Expected Outcome

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO3 - Implement encryption/decryption techniques.

IV. Laboratory Learning Outcome (LLO)

LLO 5.1: Implement caesar cipher encryption technique.

V. Relevant Affective domain related Outcomes(s)

1. Ethical awareness – Recognizing that weak ciphers should not be used in practice.
2. Analytical thinking – Understanding how shifts in the alphabet affect ciphertext.
3. Attention to detail – Ensuring correct key application in both encryption and decryption.

VI. Theoretical Background

Caesar Cipher : It is a mono-alphabetic cipher wherein each letter of the plaintext is substituted by another letter to form the ciphertext. It is the simplest form of a substitution cipher scheme.
This cryptosystem is generally referred to as the **Shift Cipher**. The concept is to replace each alphabet by another alphabet which is **shifted** by some fixed number between 0 and 25.
For this type of scheme, both sender and receiver agree on a *secret shift number* for shifting the alphabet. This number, between 0 and 25, becomes the **key** of encryption.
The name *Caesar Cipher* is occasionally used to describe the Shift Cipher when the **shift of three** is used.

Process of Shift Cipher:

- To encrypt a plaintext letter, the sender positions the sliding ruler underneath the first set of plaintext letters and slides it to the **LEFT** by the number of positions of the secret shift.
- The plaintext letter is then encrypted to the ciphertext letter on the sliding ruler underneath.

Encryption formula:

$$C = (P + K)\ mod\ 26$$

Decryption formula:

$$P = (C - K)\ mod\ 26$$

Where,
P = Plaintext letter,
C = Ciphertext letter,
K = Key (shift value).

Example:

Encryption:

Plaintext = **AISSMS**

Let’s choose a **shift key K = 3** (Caesar’s classic).

- A → (0+3) mod 26 = 3 → D
- I → (8+3) mod 26 = 11 → L
- S → (18+3) mod 26 = 21 → V
- S → (18+3) mod 26 = 21 →V
- M → (12+3) mod 26 = 15 → P
- S → (18+3) mod 26 = 21 →V

Ciphertext = DLVVPV

Decryption:

We now take the ciphertext **DLVVPV** and apply the decryption formula:

- D → (3 – 3) mod 26 = 0 → A
- L → (11 – 3) mod 26 = 8 → I
- V → (21 – 3) mod 26 = 18 → S
- V → (21 – 3) mod 26 = 18 → S
- P → (15 – 3) mod 26 = 12 → M
- V → (21 – 3) mod 26 = 18 → S

Recovered **Plaintext = AISSMS**

VII. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows XP / 7 onwards / LINUX V 5.0 or latest		
3	Tools / Software Required	Turbo C Compiler, Open source-crytool 1		

VIII. Procedure

Caesar Cipher Implementation using C program

```
Step 1: START
Step 2: Display menu and get user choice
        - Option 1: Encryption
        - Option 2: Decryption
Step 3: Accept input text from user
Step 4: Accept shift value (key) from user
Step 5: Validate and normalize shift value
        - shift = shift % 26
        - If shift is negative, add 26
Step 6: Check user choice:
        - If choice = 1, go to ENCRYPTION STEPS
        - If choice = 2, go to DECRYPTION STEPS
Step 7: Display the result (encrypted or decrypted text)
Step 8: STOP.
```

Caesar cipher technique to perform encryption and decryption of text using any open-source tool (Example – CrypTool 1.4.42)

PART A: ENCRYPTION PROCESS

Step 1: Launch CrypTool

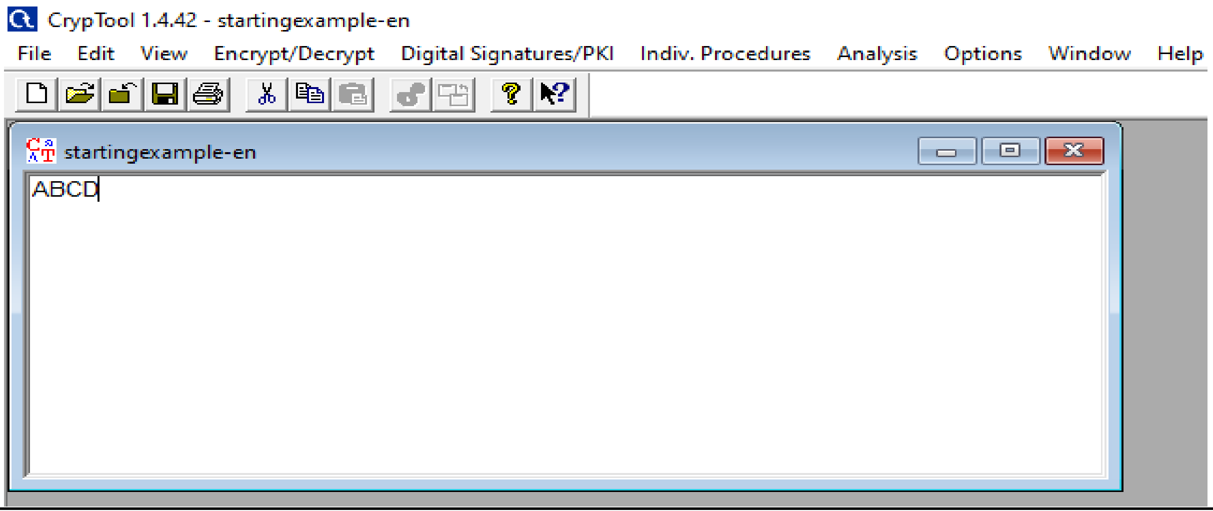
- Open **CrypTool 1.4.42** application on your computer
- Wait for the main interface to load

Step 2: Create New Document

- Click on **File** menu in the menu bar
- Select **New** to create a blank document
- A new text editor window will open

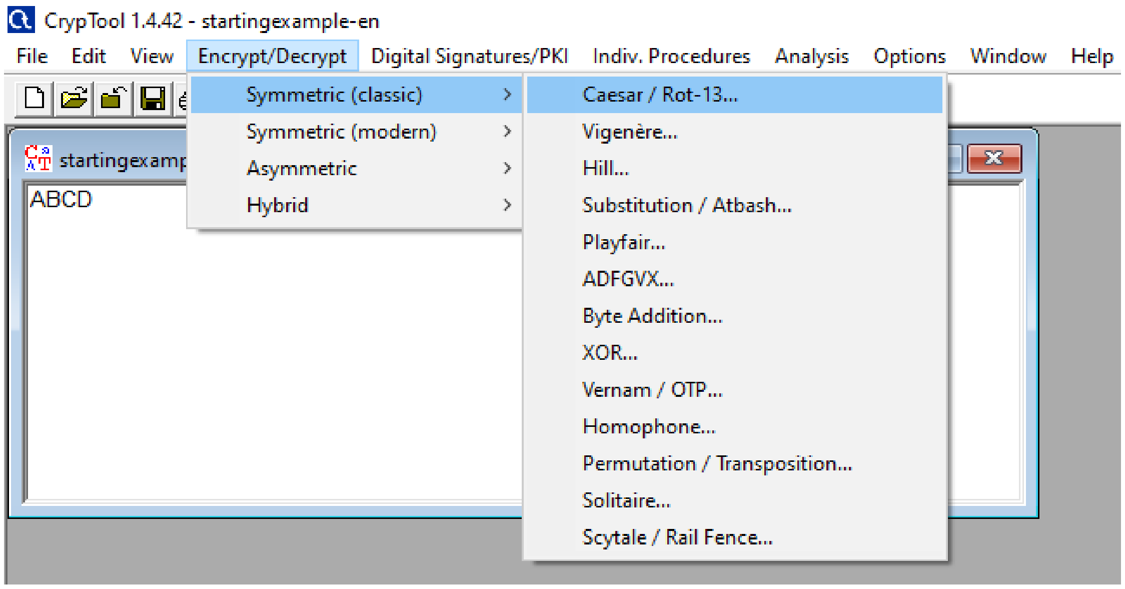
Step 3: Enter Plain Text

- In the blank document window, type your message (plain text)
- Example: "ABCD" or any text you want to encrypt
- The text can include letters, spaces, and special characters


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
ABCD

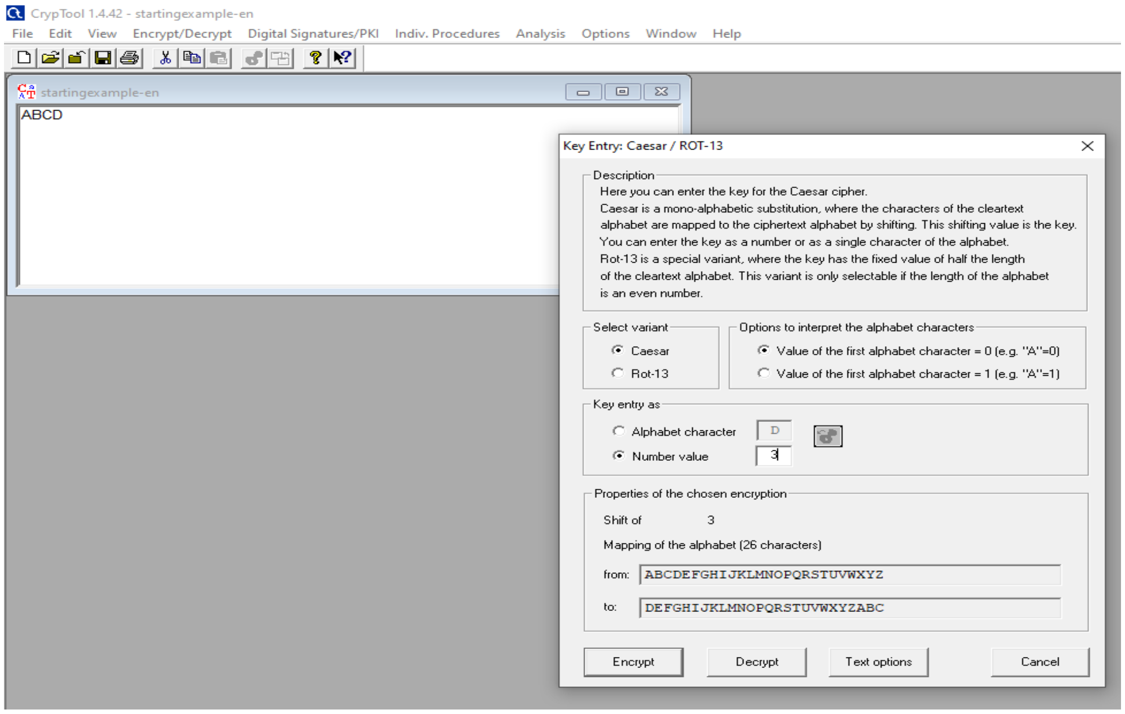
Step 4: Access Caesar Encryption

- Click on **Encrypt/Decrypt** menu from the top menu bar
- Navigate to **Symmetric (classic)**
- Select **Caesar** from the submenu
- A Caesar cipher dialog box will appear



Step 5: Configure Encryption Settings

- In the Caesar dialog box, you will see:
  - **Alphabet**: Select the character set (usually "A-Z" for English)
  - **Key (Shift Value)**: Enter the shift value (e.g., 3, 5, 13, etc.)
  - **Options**: Choose encryption/decryption mode
- Set your desired shift value (typically 1-25)


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
ABCD
Key Entry: Caesar / ROT-13
Encrypt
Decrypt
Text options
Cancel

Description
Here you can enter the key for the Caesar cipher.
Caesar is a mono-alphabetic substitution, where the characters of the cleartext alphabet are mapped to the ciphertext alphabet by shifting. This shifting value is the key.
You can enter the key as a number or as a single character of the alphabet.
Rot-13 is a special variant, where the key has the fixed value of half the length of the cleartext alphabet. This variant is only selectable if the length of the alphabet is an even number.

Select variant: [✓ Caesar] Rot-13

Options to interpret the alphabet characters: [✓ Value of the first alphabet character = 0 (e.g. "A"=0)] Value of the first alphabet character = 1 (e.g. "A"=1)

Key entry as: Alphabet character D [✓ Number value 3]

Properties of the chosen encryption
Shift of 3
Mapping of the alphabet (26 characters)
from: ABCDEFGHIJKLMNOPQRSTUVWXYZ
to: DEFGHIJKLMNOPQRSTUVWXYZABC

Step 6: Set Encryption Mode

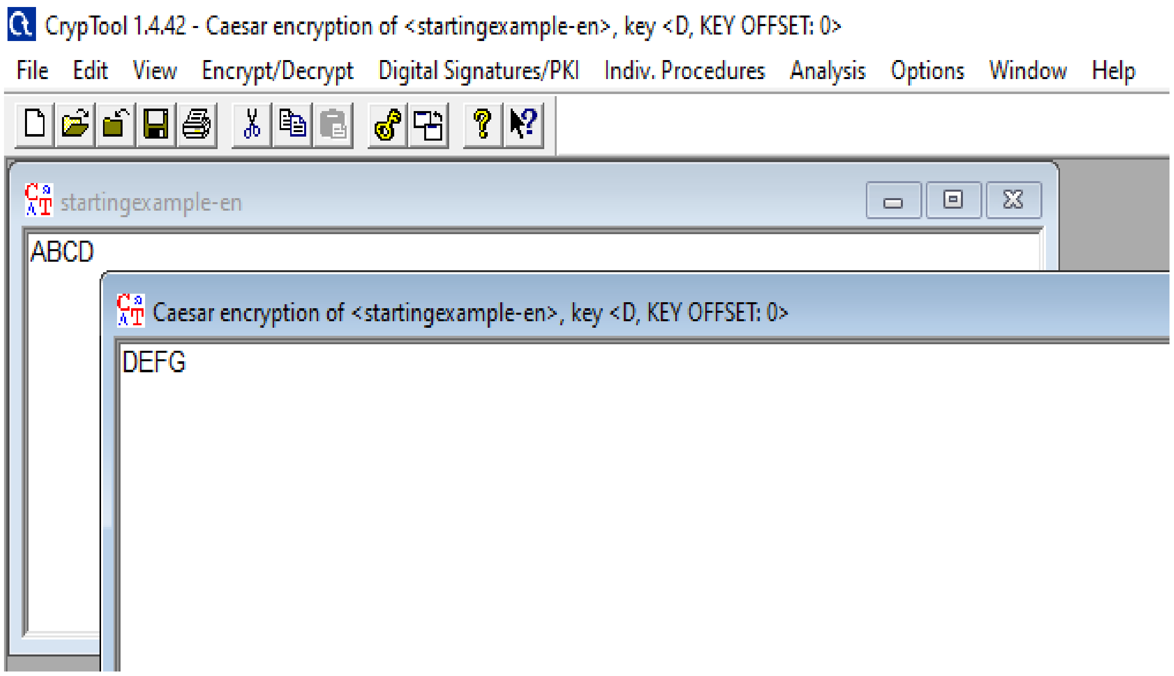
- Ensure **Encrypt** option is selected (radio button)
- Verify your shift value is correct
- Check the alphabet settings

Step 7: Execute Encryption

- Click **OK** or **Encrypt** button
- CrypTool will process your text
- A new window will open showing the encrypted text (ciphertext)

Step 8: View Encrypted Result

- The encrypted text will be displayed in a new document window
- The original plain text remains in the first window
- You can see the transformation applied to each character


CrypTool 1.4.42 - Caesar encryption of <startingexample-en>, key <D, KEY OFFSET: 0>
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
Caesar encryption of <startingexample-en>, key <D, KEY OFFSET: 0>

ABCD

DEFG

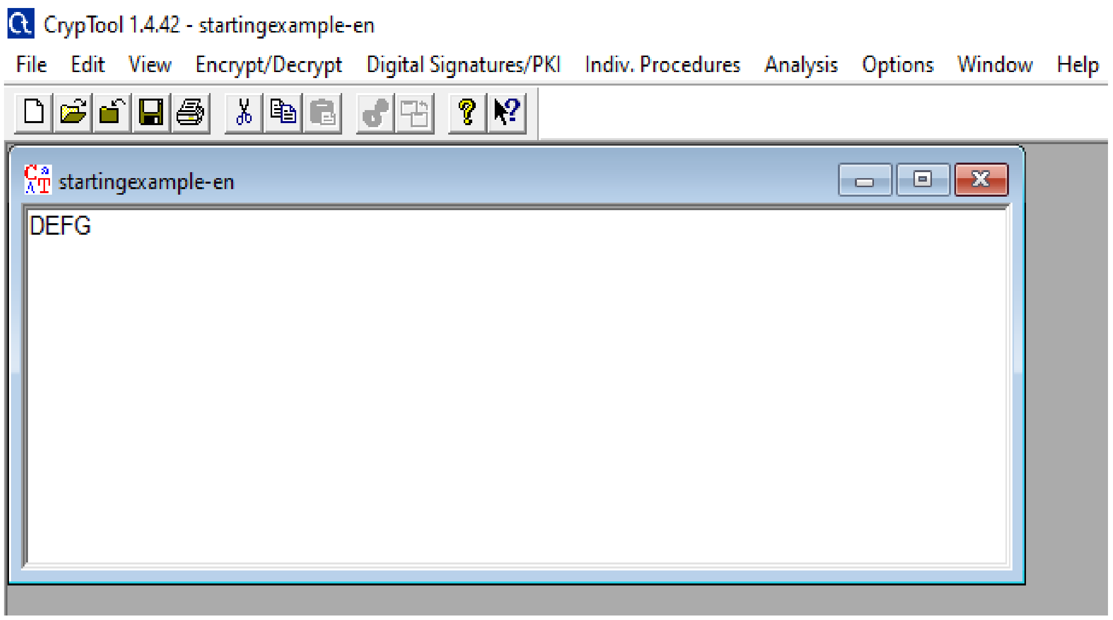
PART B: DECRYPTION PROCESS

Step 1: Open Encrypted Text

- If continuing from encryption, keep the ciphertext window active
- OR open a saved encrypted file: **File** → **Open**

Step 2: Access Caesar Decryption

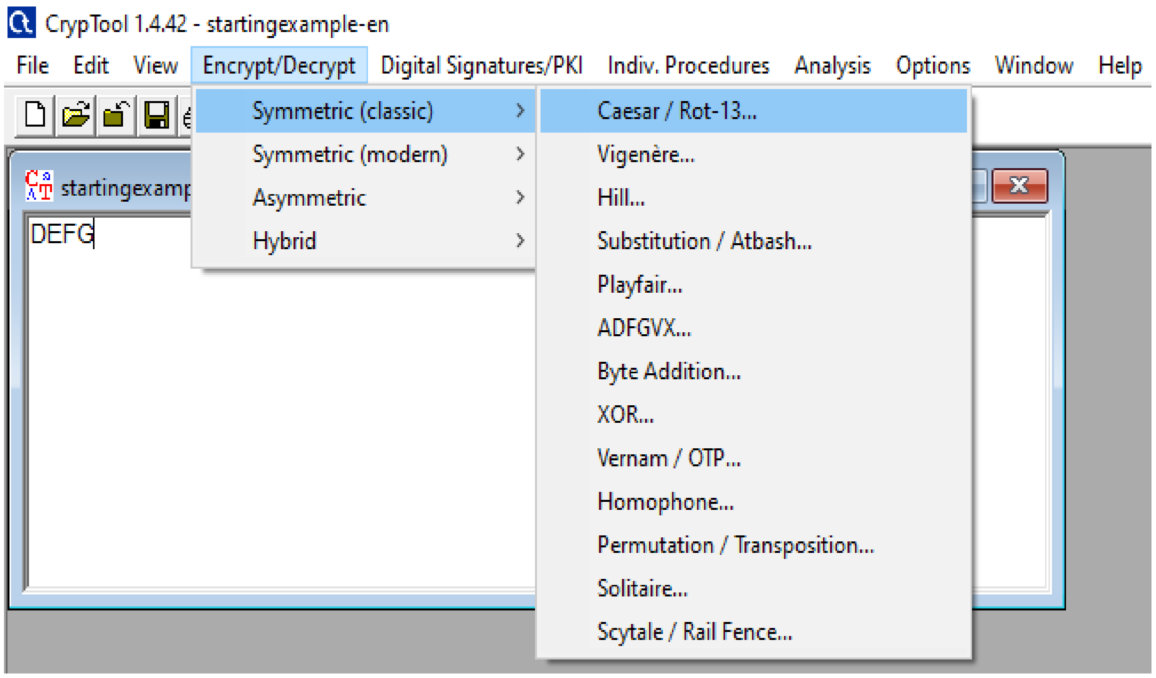
- With the encrypted text window active
- Click on **Encrypt/Decrypt** menu
- Navigate to **Symmetric (classic)** → **Caesar**
- Caesar dialog box appears again


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en

DEFG

Step 3: Configure Decryption Settings

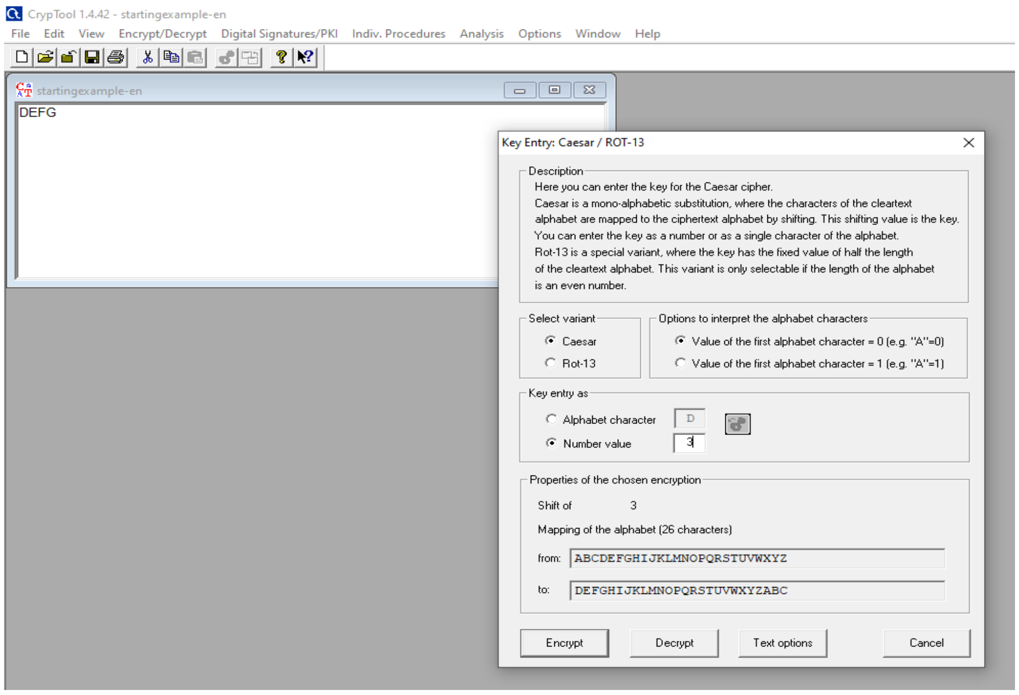
- In the Caesar dialog box:
  - **Alphabet**: Use the same alphabet as encryption
  - **Key (Shift Value)**: Enter the SAME shift value used for encryption
  - **Mode**: Select **Decrypt** option (radio button)



DEFG

Step 4: Execute Decryption

- Verify the shift value matches the encryption key
- Click **OK** or **Decrypt** button
- CrypTool will reverse the Caesar cipher


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
Encrypt
Decrypt
Text options
Cancel

DEFG

Key Entry: Caesar / ROT-13

Description
Here you can enter the key for the Caesar cipher.
Caesar is a mono-alphabetic substitution, where the characters of the cleartext alphabet are mapped to the ciphertext alphabet by shifting. This shifting value is the key.
You can enter the key as a number or as a single character of the alphabet.
Rot-13 is a special variant, where the key has the fixed value of half the length of the cleartext alphabet. This variant is only selectable if the length of the alphabet is an even number.

Select variant: [✓ Caesar] Rot-13

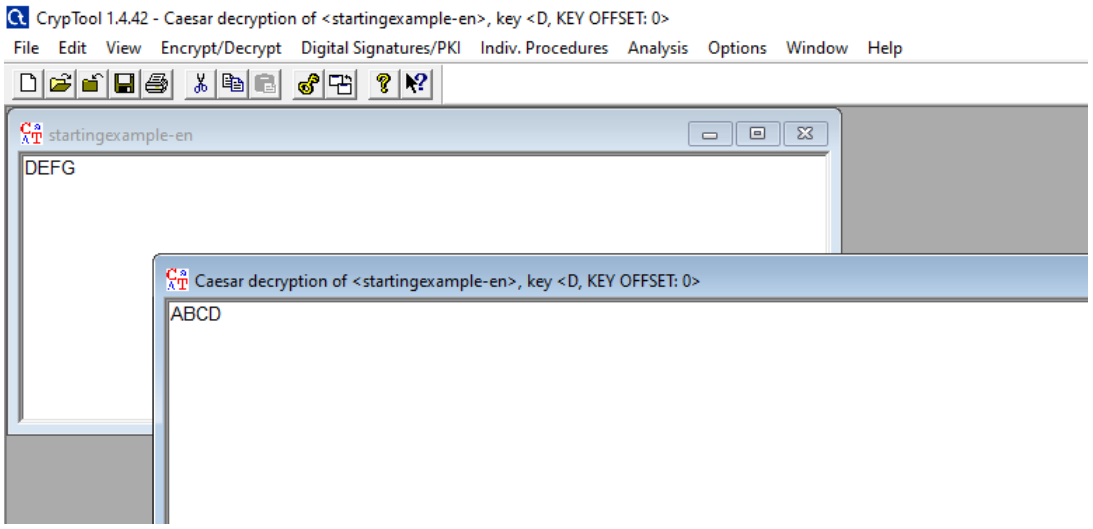
Options to interpret the alphabet characters: [✓ Value of the first alphabet character = 0 (e.g. "A"=0)] Value of the first alphabet character = 1 (e.g. "A"=1)

Key entry as: Alphabet character D [✓ Number value 3]

Properties of the chosen encryption
Shift of 3
Mapping of the alphabet (26 characters)
from: ABCDEFGHIJKLMNOPQRSTUVWXYZ
to: DEFGHIJKLMNOPQRSTUVWXYZABC

Step 5: View Decrypted Result

- A new window opens displaying the decrypted text
- Compare with original plain text to verify correctness
- The text should match your original message


CrypTool 1.4.42 - Caesar decryption of <startingexample-en>, key <D, KEY OFFSET: 0>
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
Caesar decryption of <startingexample-en>, key <D, KEY OFFSET: 0>

DEFG

ABCD

Step 6: Verify Results

- Check that decrypted text = original plain text
- If incorrect, verify the shift value was correct

IX. Precautions

1. Always use correct key during encryption and decryption.
2. Ensure input text contains only alphabets for predictable results.
3. Save original plaintext before testing to avoid data loss.
4. Do not confuse Caesar cipher with modern strong encryption (AES, RSA).

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Describe working of Caesar cipher with an example.
2. Why is Caesar cipher considered insecure?
3. Consider plain text "NETWORK" and convert given plain into cipher text.
4. Implement Caesar cipher for numeric digits in addition to alphabets
5. Compare Caesar cipher with Columnar Transposition cipher in terms of strength and weaknesses.

Space for Answer

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XI. Exercise

1. Modify the C program to handle both uppercase and lowercase input correctly.
2. Extend the program to allow brute-force decryption without a key.
3. Compare Caesar cipher with Modified Caesar cipher in terms of security.

XII. References / Suggestions for further reading

1. Stallings, W. Cryptography and Network Security: Principles and Practice.
2. Kahate, A. Cryptography and Network Security.
3. CrypTool Official Website: https://www.cryptool.org
4. NPTEL Course: Introduction to Cryptography and Network Security.
5. Virtual Labs, IIIT Hyderabad, n.d. Cryptography Experiments. Available at: https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html

XIII. Assessment schemes

Performance Indicators		Weightage
Process related (15 Marks)		**60 %**
1	Correct implementation of Caesar cipher in C	20 %
2	Successful use of CrypTool for encryption/decryption	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Correctness of ciphertext and plaintext recovery	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 06: i. Implement Vernam cipher encryption technique to perform encryption of text using C programming language ii. Apply Vernam cipher technique to perform encryption and decryption of text using any open-source tool (Example - Cryptool)

I. Practical Significance

This practical introduces the Vernam cipher, a stream cipher based on the XOR operation. Unlike substitution ciphers, Vernam cipher provides a stronger encryption approach when combined with a truly random key (known as a One-Time Pad). Students will implement Vernam cipher in C and also apply it using open-source tools such as CrypTool, helping them understand the significance of randomness and key length in cryptographic security.

II. Industry / Employer Expected Outcome

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO3 – Implement encryption/decryption techniques.

IV. Laboratory Learning Outcome (LLO)

LLO 6.1: Implement Vernam cipher encryption technique.

V. Relevant Affective domain related Outcomes(s)

1. Ethical awareness: Understanding limitations of using short keys versus one-time pad.
2. Analytical skills: Linking bitwise operations to cryptographic principles.
3. Responsibility: Correct handling of encryption keys.

VI. Theoretical Background

Vernam Cipher:

The Vernam Cipher is a symmetric key stream cipher invented in 1917 by Gilbert Vernam.

It operates by applying the XOR (Exclusive OR) logical operation between each bit of the plaintext and a corresponding bit of the key.

This makes it different from simple substitution ciphers because encryption and decryption use the same XOR function.

Process Vernam Cipher:

1. Key Selection

- Choose a **key** of the **same length as the plaintext**.
- If the key is truly random and never reused, the cipher becomes a **One-Time Pad (OTP)**.

2. Convert Plaintext and Key to Binary/Numbers

- Represent plaintext letters and key letters as **ASCII binary codes** (or A=0, B=1, …, Z=25 if working mod 26).

3. Encryption (XOR Operation)

- Apply **bitwise XOR (⊕)** between each bit of the plaintext and key.

$$C = P \oplus K$$

4. Ciphertext Formation

- Combine all XOR results to get the **ciphertext in binary**.
- Convert the binary back into characters (may look random).

5. Decryption

- Receiver applies XOR again with the same key:

$$P = C \oplus K$$

- Since XOR is reversible, applying the same operation restores the original plaintext.

Where,

P = Plaintext letter,

C = Ciphertext letter,

K = Key (shift value).

⊕ = XOR

Example:

Encryption:

Plaintext = **AISSMS**

- **Plaintext → Numbers (A=0, B=1, …, Z=25)**
- A = 0
- I = 8
- S = 18
- S = 18
- M = 12
- S = 18

So, Plaintext = **0 8 18 18 12 18**

- **Choose a Key (same length as plaintext)**

Let's take Key = **XMCKLQ**

- X = 23
- M = 12
- C = 2
- K = 10
- L = 11
- Q = 16

So, Key = **23 12 2 10 11 16**

- **Encryption Formula**

C=(P+K)mod 26C = (P + K) \mod 26C=(P+K)mod26

Now compute:

- A (0) + X (23) = 23 → **X**
- I (8) + M (12) = 20 → **U**
- S (18) + C (2) = 20 → **U**
- S (18) + K (10) = 28 mod 26 = 2 → **C**

- M (12) + L (11) = 23 → **X**
- S (18) + Q (16) = 34 mod 26 = 8 → **I**
- **Ciphertext**

Ciphertext = XUUCXI

VII. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows XP / 7 onwards / LINUX V 5.0 or latest		
3	Tools / Software Required	Turbo C Compiler, Open source-crytool 1		

VIII. Procedure

Vernam Cipher Implementation using C program

Step 1: START

Step 2: INPUT PLAINTEXT

- Accept plaintext from user
- Store in plaintext array

Step 3: PREPROCESS PLAINTEXT

- Convert all characters to uppercase
- Remove spaces and non-alphabetic characters
- Store in processedPlaintext array

Step 4: CALCULATE LENGTH

- Determine length of processed plaintext
- Store as variable n

Step 5: VALIDATE PLAINTEXT

- Check if length > 0
- If length = 0, display error and EXIT
- Otherwise, continue

Step 6: INPUT KEY

- Accept key from user
- Key length must be ≥ plaintext length

Step 7: PREPROCESS KEY

- Convert all characters to uppercase
- Remove spaces and non-alphabetic characters
- Store in processedKey array

Step 8: VALIDATE KEY LENGTH

- Check if key length ≥ plaintext length

- If key is too short, display error and EXIT
- Otherwise, trim key to match plaintext length

Step 9: CONVERT TO NUMBERS

- Convert plaintext characters to numbers (A=0, B=1, ..., Z=25)
- Convert key characters to numbers (A=0, B=1, ..., Z=25)

Step 10: PERFORM ENCRYPTION

- For each position i (0 to n-1):
  - Apply formula: C[i] = (P[i] + K[i]) mod 26
- Store results in ciphertext array

Step 11: CONVERT BACK TO CHARACTERS

- Convert numeric ciphertext to characters (0=A, 1=B, ..., 25=Z)

Step 12: DISPLAY RESULTS

- Show plaintext, key, and ciphertext
- Display numeric representations

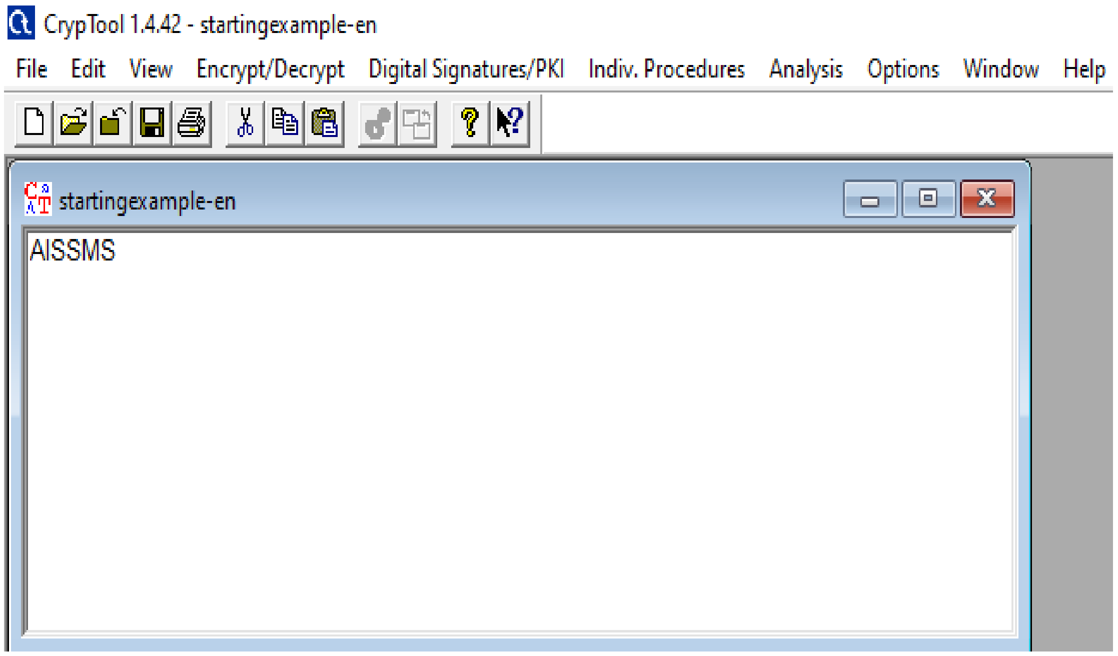
Step 13: STOP

Caesar cipher technique to perform encryption and decryption of text using any open-source tool (Example – CrypTool 1.4.42)

PART A: ENCRYPTION PROCESS

Step 1: Launch CrypTool

- Open CrypTool 1.4.42 application on your computer
- Create a new text window in CrypTool (File → New → Textfile or click the new-document button) and type your plaintext (example: AISSMS as in your screenshot). Leave that CrypTool editor window active.Step 2: Create New Document



AISSMS

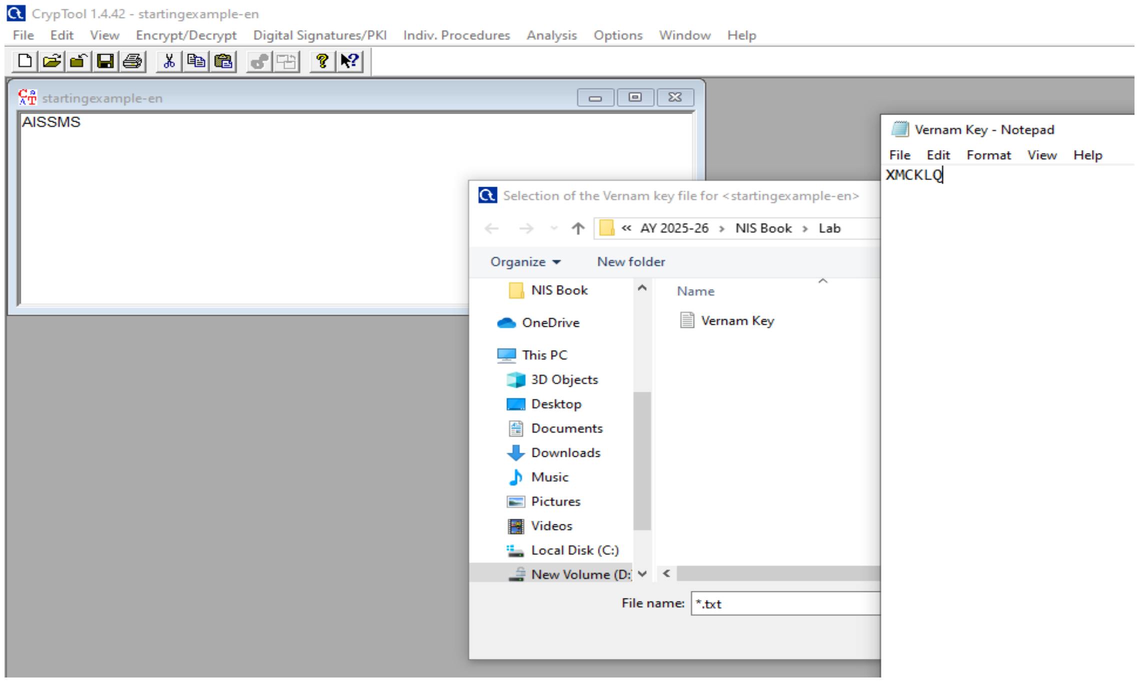
Step 2: Create & save the key file

- Open **Notepad** (or Notepad++). Type your key characters.

- The key must be at least as long as the plaintext (preferably exactly the same length for a demo or truly random one-time pad in real OTP use).
- Example key you used: XMKCLQ.

- Save the key file: **File** → **Save As** → choose a folder, give it a name like Vernam Key.txt.

Important: set Encoding = **ANSI** (or "UTF-8 without BOM") to avoid a byte-order-mark (BOM) being inserted. Click Save.


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
Selection of the Vernam key file for <startingexample-en>
AY 2025-26 > NIS Book > Lab
Organize New folder
NIS Book
OneDrive
This PC
3D Objects
Desktop
Documents
Downloads
Music
Pictures
Videos
Local Disk (C:)
New Volume (D:
Name
Vernam Key
File name:
Vernam Key - Notepad
File Edit Format View Help

AISSMS

XMCKLQ

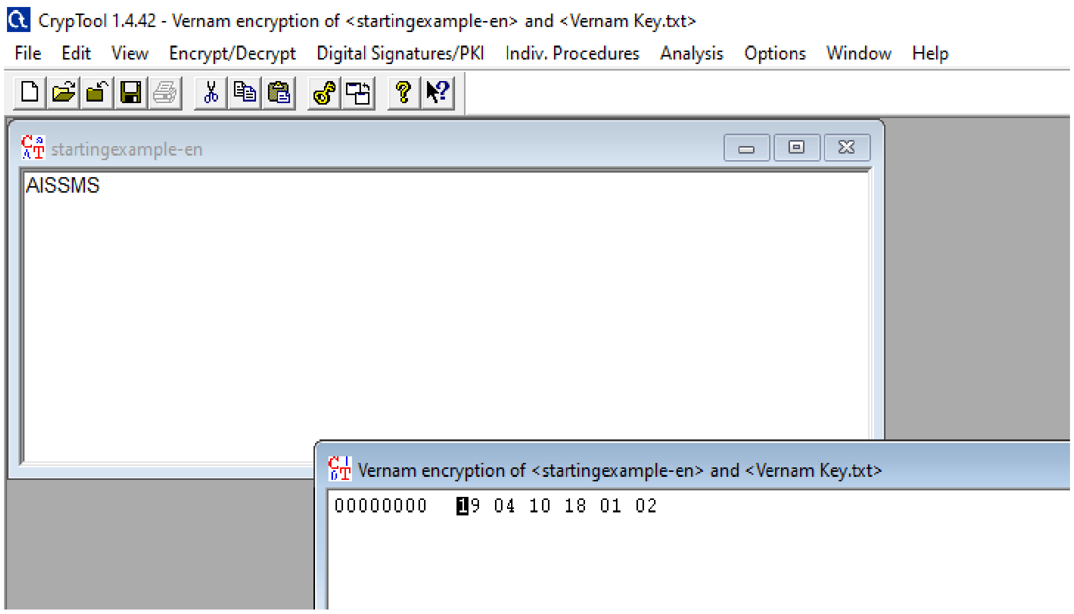
*.txt

Step 3: Encrypt with Vernam (XOR)

- In CrypTool, with the plaintext window active go to:

Encrypt/Decrypt → Symmetric (Classic) → Vernam / OTP...

- A file-selection dialog will open asking you to select the Vernam key file. Navigate to and select the Vernam Key.txt you saved. (If CrypTool offers options like reading as text/hex, choose **text** / default.)
- CrypTool will perform the Vernam operation (byte-wise XOR of plaintext bytes with key bytes). It will open a small hex output window showing the XOR bytes and will create a new text window containing the ciphertext (or show ciphertext as a binary/hex view). You can save that ciphertext window (File → Save As) if desired.


CrypTool 1.4.42 - Vernam encryption of <startingexample-en> and <Vernam Key.txt>
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
Vernam encryption of <startingexample-en> and <Vernam Key.txt>

AISSMS

```
00000000   19 04 10 18 01 02
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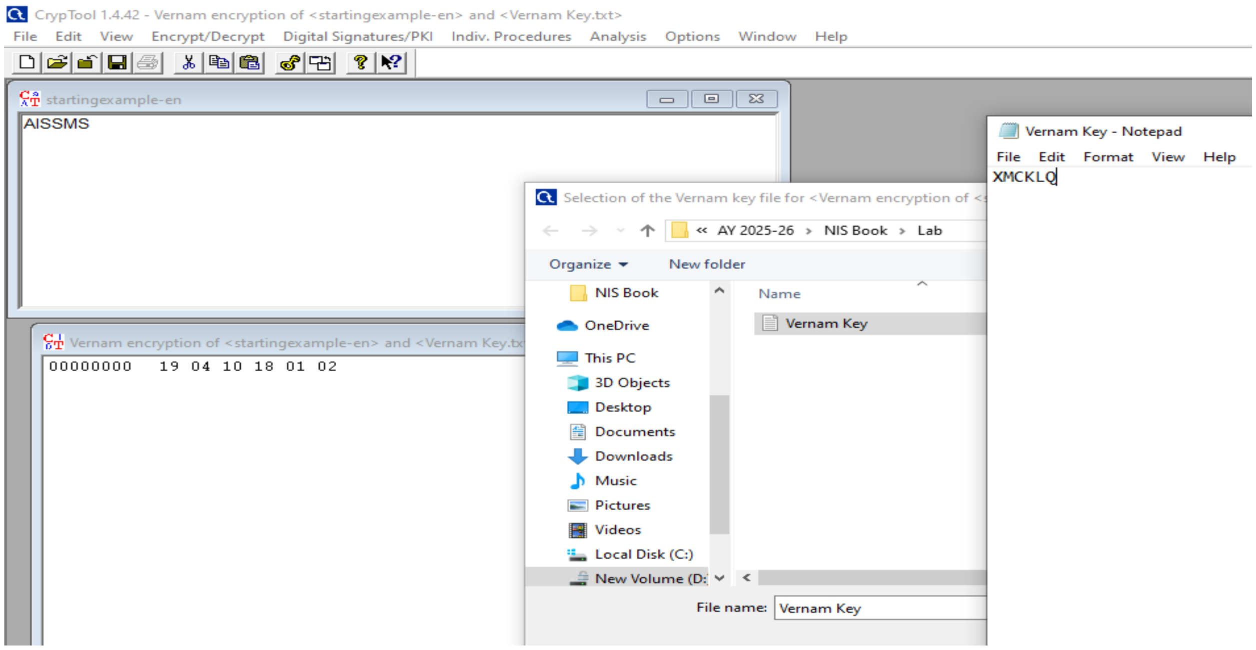
PART B: DECRYPTION PROCESS

Step 1: Open Encrypted Text

- If continuing from encryption, keep the ciphertext window active
- OR open a saved encrypted file: **File → Open**


CrypTool 1.4.42 - Vernam encryption of <startingexample-en> and <Vernam Key.txt>
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
Vernam encryption of <startingexample-en> and <Vernam Key.tx
Selection of the Vernam key file for <Vernam encryption of <
« AY 2025-26 › NIS Book › Lab
Organize New folder
NIS Book
OneDrive
This PC
3D Objects
Desktop
Documents
Downloads
Music
Pictures
Videos
Local Disk (C:)
New Volume (D:
Name
Vernam Key
File name: Vernam Key
Vernam Key - Notepad
File Edit Format View Help

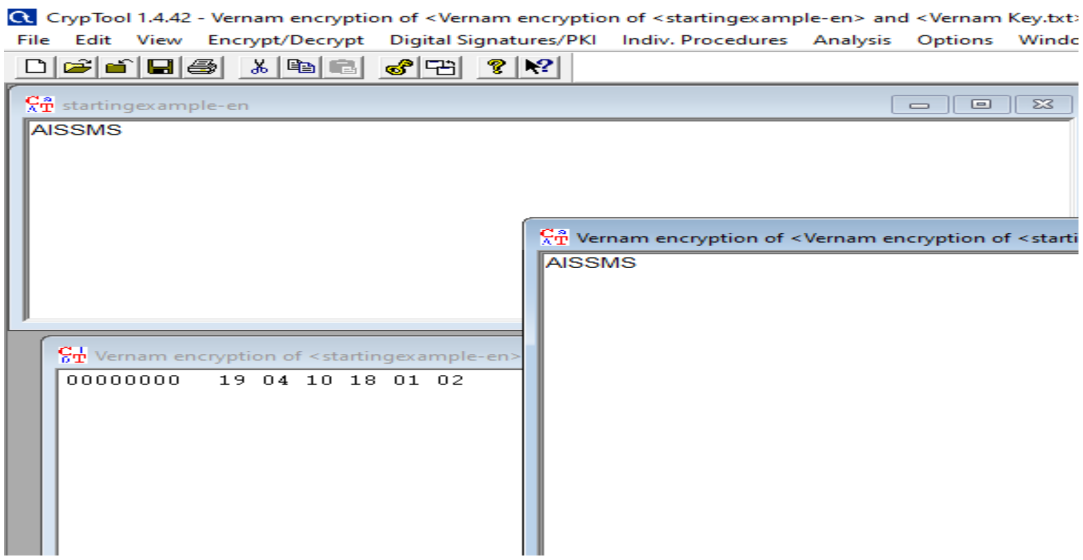
AISSMS

```
00000000   19 04 10 18 01 02
```

XMCKLQ

Step 2: Decrypt

- To decrypt: open (or keep) the ciphertext in a CrypTool text window and repeat Encrypt/Decrypt → Symmetric (Classic) → Vernam / OTP... and select the same key file.
- Vernam/OTP is self-inverse: applying the same XOR key to ciphertext returns the original plaintext, so the same menu action decrypts it.
- The result should appear as the original plaintext in a new window.


CrypTool 1.4.42 - Vernam encryption of <Vernam encryption of <startingexample-en> and <Vernam Key.txt
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Windo
startingexample-en
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Vernam encryption of <startingexample-en>

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AISSMS
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AISSMS
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00000000    19  04  10  18  01  02
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IX. Precautions

1. Key length must equal plaintext length.
2. Keys must remain secret and used only once.
3. Save test data to verify correctness.

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. State the encryption and decryption formulas for Vernam cipher.
2. Differentiate between Caesar cipher and Vernam cipher.
3. Encrypt your name using CrypTool with Vernam cipher and attach a screenshot.
4. Implement Vernam cipher to encrypt the string "NETWORK"

Space for Answer

XI. Exercise

1. Modify the C program to accept keys in binary format.
2. Demonstrate encryption of a paragraph of text using Vernam cipher.
3. Compare Vernam cipher with modern stream ciphers (RC4, Salsa20).

XII. References / Suggestions for further reading

1. Stallings, W. Cryptography and Network Security: Principles and Practice.
2. Kahate, A. Cryptography and Network Security.
3. CrypTool Official Website: https://www.cryptool.org
4. NPTEL Course: Introduction to Cryptography and Network Security.
5. Virtual Labs, IIIT Hyderabad, n.d. Cryptography Experiments. Available at: https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html

XIII. Assessment schemes

Performance Indicators		Weightage
Process related (15 Marks)		**60 %**
1	Correct implementation of Vernam cipher in C	20 %
2	Successful use of CrypTool for encryption/decryption	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Correctness of ciphertext and plaintext recovery	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical Number: 07: Implement railfence encryption technique to perform encryption of text using C programming language.

I. Practical Significance:

This practical demonstrates the Rail Fence cipher, a transposition cipher that rearranges characters in a zig-zag pattern across multiple "rails." Unlike substitution ciphers, Rail Fence does not alter the characters themselves but changes their order, introducing the concept of transposition techniques in cryptography.

II. Industry / Employer Expected Outcome:

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s):

CO3 – Implement encryption/decryption techniques.

IV. Laboratory Learning Outcome (LLO):

LLO 7.1**:** Implement railfence encryption technique.

V. Relevant Affective domain related Outcomes(s):

1. Analytical skills: Recognizing how rearrangement of characters alters ciphertext.
2. Attention to detail: Correctly implementing row and column arrangement.
3. Responsibility: Verifying encryption/decryption results with different keys (rails).

I. Theoretical Background

Rail Fence Cipher: The Rail Fence cipher is a transposition cipher that arranges plaintext letters diagonally in a zigzag pattern across multiple rails (rows).Ciphertext is obtained by reading characters row by row.

Example:

Choose a key = number of rails.
Write plaintext in a zigzag manner on rails.
Read text row-wise → Ciphertext.
For decryption, reconstruct zigzag pattern using ciphertext and number of rails.
Example (2-rail cipher):
Plaintext: HELLO WORLD
Arrangement:

```
H . L . O . W . R . D
. E . L .   . O . L .
```

Ciphertext: HLOWRDELOL

II. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows XP / 7 onwards / LINUX V 5.0 or latest		
3	Tools / Software Required	Turbo C Compiler		

III. Procedure

Rail Fence Cipher Implementation using C program

Step 1: START

Step 2: Input the plaintext message.
Example: "HELLO WORLD"

Step 3: Remove spaces (or store their positions if you want to restore them later).
Result: "HELLOWORLD"

Step 4: Input the key (number of rails).
Example: key = 2

Step 5: Initialize a 2D array rail[key][length_of_text] and fill all positions with a marker (e.g., '\n').

Step 6: Set direction flag down = false and row = 0.

Step 7: For each character in plaintext:
a. Place the character in rail[row][col].
b. If row == 0, set down = true.
c. Else if row == key - 1, set down = false.
d. Move to next column.
e. If down == true, row++; else row--.

Step 8: After filling the matrix, read all characters row by row to form ciphertext.

Step 9: Display ciphertext.

Step 10: STOP.

IV. Precautions

- The number of rails must be less than the length of plaintext.
- Spaces and punctuation should be handled consistently (removed or preserved).
- Encryption and decryption must use the same number of rails (key).

V. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. State the difference between substitution and transposition techniques.
2. Explain the working of the Rail Fence cipher with an example

3. Encrypt the text "CRYPTOGRAPHY" using 3-rail cipher.
4. Design a Rail Fence cipher program that supports both encryption and decryption modes in one implementation.

Space for Answer

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VI. Exercise

1. Modify program to preserve spaces in ciphertext.
2. Implement Rail Fence cipher with a GUI interface in C or Python.
3. Compare results of encryption for 2 rails, 3 rails, and 4 rails with the same plaintext.

VII. References / Suggestions for further reading

1. Stallings, W. Cryptography and Network Security: Principles and Practice.
2. Kahate, A. Cryptography and Network Security.
3. NPTEL Course: Introduction to Cryptography and Network Security.
4. Virtual Labs, IIIT Hyderabad, n.d. Cryptography Experiments. Available at: https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html

VIII. Assessment schemes

Performance Indicators		Weightage
Process related (15 Marks)		**60 %**
1	Correct implementation of Rail Fence cipher in C	20 %
2	Demonstration of working with different keys	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Correctness of ciphertext and plaintext recovery	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 08: Implement simple Columnar Transposition encryption technique to perform encryption of text using C programming language.

I. Practical Significance

This practical demonstrates the Columnar Transposition Cipher, one of the classical transposition techniques where the order of plaintext characters is rearranged according to a predefined key. It introduces students to the concepts of columnar arrangement, permutation, and reading ciphertext column-wise. By implementing this cipher in C, students understand the importance of positional rearrangement in cryptography.

II. Industry / Employer Expected Outcome

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO3 – Implement encryption/decryption techniques.

IV. Laboratory Learning Outcome (LLO)

LLO 8.1: Implement simple columnar transposition technique.

V. Relevant Affective domain related Outcomes(s)

1. Analytical skills: Rearranging data systematically according to a given key.
2. Attention to detail: Handling incomplete rows and padding characters.
3. Responsibility: Applying correct key order for both encryption and decryption.

VI. Theoretical Background

Columnar Transposition Cipher:

A Columnar Transposition Cipher is a classical encryption technique that rearranges the letters of the plaintext into a fixed column structure according to a key. Unlike substitution ciphers that replace letters with others, this method changes only the positions of characters, making the ciphertext a permutation of the original message.

The Columnar Transposition Cipher works on the principle of transposition, where the sequence of characters is altered while preserving their original identities. To encrypt, a key (word or number) is chosen, and the plaintext is written into a grid with as many columns as the length of the key. The columns are then rearranged according to the alphabetical order of the key characters (or numerical order if digits are used). Finally, the ciphertext is generated by reading the letters column by column. This cipher is relatively simple but offers stronger security compared to direct substitution since frequency analysis becomes less effective. However, it can still be broken using known-plaintext or brute force attacks. Columnar transposition is often combined with substitution methods to create product ciphers for enhanced security.

Example:
Plaintext: POLYTECHNIC
Key: COMP
Step 1: Number the Key
We order the letters in **alphabetical order**:
Key = **C O M P**

- C → 1
- M → 2
- O → 3
- P → 4

So key = **1 3 2 4**
Step 2: Arrange Plaintext in Grid
Plaintext length = 11 letters
Key length = 4 → grid has 4 columns
We write row by row and add padding X to fill:
Key: 1 3 2 4

C	**O**	**M**	**P**
1	**3**	**2**	**4**
P	O	L	Y
T	E	C	H
N	I	C	X

Step 3: Read Columns in Order
Rearrange columns according to key order (1 → 2 → 3 → 4):

- Column Name 1 → P T N
- Column Name 2 → L C C
- Column Name 3 → O E I
- Column Name 4 → Y H X

Step 4: Ciphertext
Now read column by column:
PTNLCCOEIYHX
Final **Ciphertext** = **PTNLCCOEIYHX**

VII. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows XP / 7 onwards / LINUX V 5.0 or latest		
3	Tools / Software Required	Turbo C Compiler		

VIII. Procedure

Columnar Transposition Cipher implementation using C program

Step 1: START

Step 2: Take input from the user:
- Plaintext
- Key

Step 3: Remove all spaces from the plaintext.
Convert both the plaintext and key to **uppercase** letters.

Step 4: Determine the length of the key → keyLen
Determine the length of the plaintext → textLen

Step 5: Number the letters of the key:
a. Arrange key letters in **alphabetical order**.
b. Assign sequential numbers 1, 2, 3, … according to their order.
Example: Key = ZEBRA → Order = 5 2 1 3 4

Step 6: Create a table (matrix) with:
- **Columns = keyLen**
- **Rows = ceil(textLen / keyLen)**

Step 7: Fill the table **row by row** with letters of the plaintext.
If any empty boxes remain, **fill them with 'X'** as padding.

Step 8: Read the letters **column by column** according to the order of key numbers
(1 → 2 → 3 → … → keyLen).

Step 9: Concatenate all letters read in Step 8 to form the **Ciphertext**.

Step 10: Display the Ciphertext.

Step 11: STOP

IX. Precautions

1. Ensure key contains no repeated letters (or handle them carefully).
2. Always pad plaintext so matrix is completely filled.
3. Encryption and decryption must use exactly the same key.

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Explain the encryption process of Columnar Transposition with an example.
2. Encrypt the text "CRYPTOGRAPHY IS FUN" using the key "CIPHER".
3. Compare Columnar Transposition with Rail Fence cipher.
4. Design a hybrid encryption method combining Caesar cipher and Columnar Transposition.

Space for Answer

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XI. Exercise

1. Modify program to allow decryption as well.
2. Extend Columnar Transposition cipher to support numeric digits.
3. Implement the cipher using both row-major and column-major ordering and compare results.

XII. References / Suggestions for further reading

1. Stallings, W. Cryptography and Network Security: Principles and Practice.
2. Kahate, A. Cryptography and Network Security.
3. NPTEL Course: Introduction to Cryptography and Network Security.
4. Virtual Labs, IIIT Hyderabad, n.d. Cryptography Experiments. Available at: https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html

XIII. Assessment schemes

Performance Indicators		Weightage
Process related (15 Marks)		**60 %**
1	Correct implementation of Columnar Transposition cipher in C	20 %
2	Handling of key ordering	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Correctness of ciphertext	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 09: Create and verify Hash Code for given message using any Open-source tool (Example-Cryptool).

I. Practical Significance

This practical introduces hash functions, which are mathematical algorithms that transform input data into a fixed-size hash value (digest). Hash codes are widely used in data integrity verification, password storage, and digital signatures. Students will learn to generate and verify hash codes for a given message using open-source tools such as CrypTool.

II. Industry / Employer Expected Outcome

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO3 – Implement encryption/decryption techniques.

IV. Laboratory Learning Outcome (LLO)

LLO 9.1: Generate hash code.

V. Relevant Affective domain related Outcomes(s)

1. Responsibility: Correctly applying tools to verify message integrity.
2. Ethical awareness: Understanding risks of weak hash algorithms (e.g., MD5 collisions).
3. Analytical skills: Comparing outputs of different hash algorithms.

VI. Theoretical Background

A **hash function** is a special mathematical function that converts an input of any size (called a *message*) into a fixed-size string of characters (called a *hash value*, *digest*, or *checksum*). It is commonly used in cryptography, computer security, and data integrity verification.
A hash function takes arbitrary input data and produces a fixed-length output, usually represented as a sequence of hexadecimal characters. The key property of a hash function is that even a tiny change in the input produces a drastically different output (called the **avalanche effect**).
In computer science, hash functions are widely used in:

- **Cryptography** (e.g., SHA-256, MD5, SHA-3) to protect passwords and digital signatures.
- **Data integrity** (detecting if a file or message has been tampered with).
- **Hash tables** (for efficient data retrieval in constant time).

A **cryptographic hash function** must satisfy:

1. **Deterministic** – Same input always gives the same output.
2. **Pre-image resistance** – Hard to reverse-engineer the input from the hash.
3. **Collision resistance** – Hard to find two different inputs that produce the same hash.
4. **Avalanche effect** – Small input change gives a very different hash output.

Common Hash Algorithms:

- **MD5 (128-bit digest)** – Fast but insecure due to collisions.
- **SHA-1 (160-bit digest)** – Stronger but broken for cryptographic purposes.
- **SHA-256 (256-bit digest)** – Strong, widely used in blockchain and digital signatures.

MD5 Hash Function

- **MD5** (Message Digest 5) is a widely known hash function.
- It produces a **128-bit (16-byte) hash value**, usually represented as a **32-digit hexadecimal number**.
- It is **fast** and still used for checksums, but it is **not secure** for cryptography (because collisions can be found).

Example:

Input (Plaintext):

POLYTECHNIC

Output (MD5 Hash Value):

361dd8f32c3b59f9a5c0d6a5c1f4f40

If the input changes slightly, the hash output changes completely:

Input (Plaintext):

polytechnic

Output (MD5 Hash Value):

268d5f6e72d0d6f471a96a1740b5e5e4

VII. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows XP / 7 onwards / LINUX V 5.0 or latest		
3	Tools / Software Required	CrypTool 1.4.42		

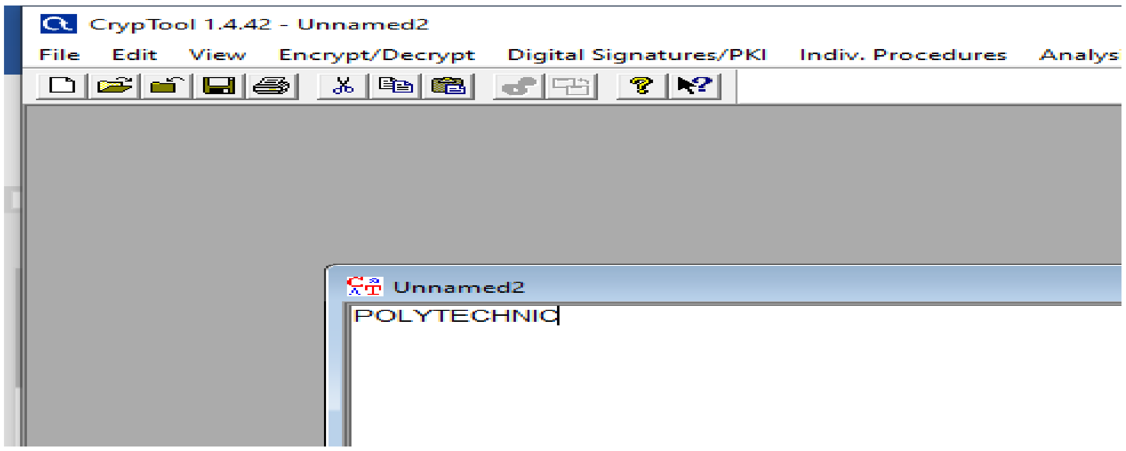
VIII. Procedure

Create and verify Hash Code (MD-5) for given message using CrypTool

Step 1: Start CrypTool 1.4.2.

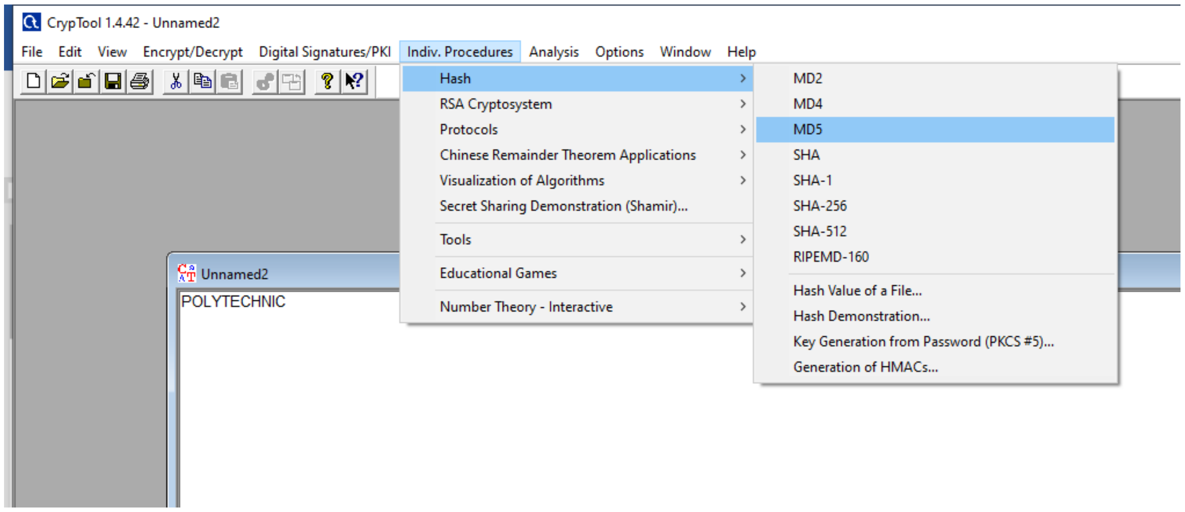
Step 2: Select **File → New** to create a new document.

Step 3:Type the plaintext (example: POLYTECHNIC) into the editor window.

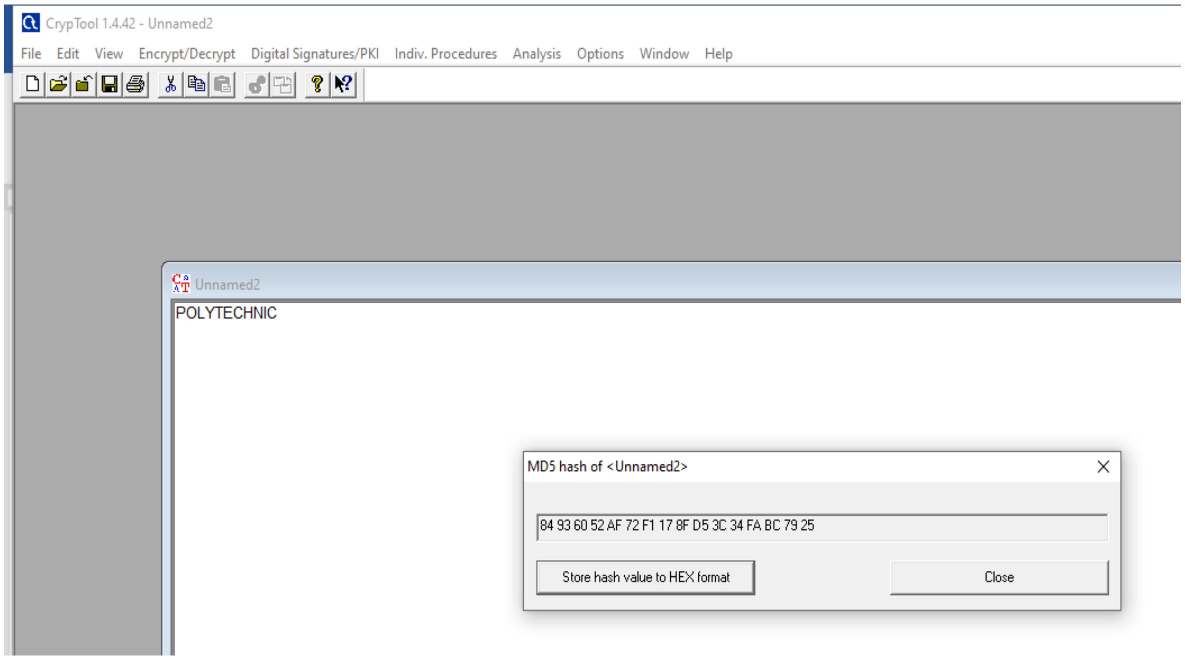

CrypTool 1.4.42 - Unnamed2
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analys
Unnamed2

POLYTECHNIC

Step 4: From the menu, go to **Indiv. Procedures → Hash → MD5.**

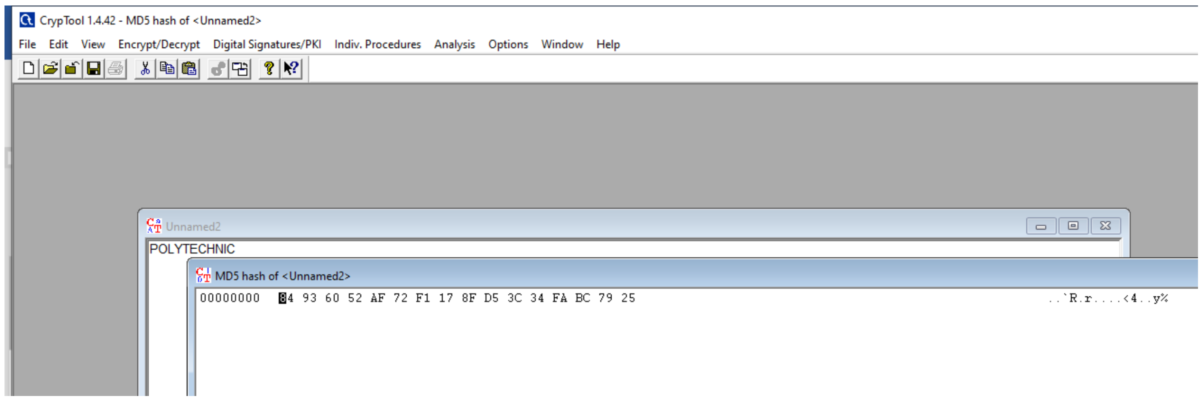

CrypTool 1.4.42 - Unnamed2
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
Hash
RSA Cryptosystem
Protocols
Chinese Remainder Theorem Applications
Visualization of Algorithms
Secret Sharing Demonstration (Shamir)...
Tools
Educational Games
Number Theory - Interactive
MD2
MD4
MD5
SHA
SHA-1
SHA-256
SHA-512
RIPEMD-160
Hash Value of a File...
Hash Demonstration...
Key Generation from Password (PKCS #5)...
Generation of HMACs...
Unnamed2
POLYTECHNIC

Step 5: A dialog box will appear showing the **MD5 hash value** in hexadecimal form.


CrypTool 1.4.42 - Unnamed2
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
Unnamed2
POLYTECHNIC
MD5 hash of <Unnamed2>
Store hash value to HEX format
Close

```
84 93 60 52 AF 72 F1 17 8F D5 3C 34 FA BC 79 25
```

Step 6: If required, click **Store hash value to HEX format** to open the hash in a new window.


CrypTool 1.4.42 - MD5 hash of <Unnamed2>
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
Unnamed2
MD5 hash of <Unnamed2>

POLYTECHNIC

```
00000000   84 93 60 52 AF 72 F1 17 8F D5 3C 34 FA BC 79 25          ..`R.r....<4..y%
```

Step 7: Copy the hex values (remove spaces if needed) to form the **32-character MD5 string**.

IX. Precautions

1. Always use strong hash functions (SHA-256 or higher) for secure applications.
2. Do not rely on MD5 or SHA-1 for cryptographic security.
3. Ensure consistent input (case-sensitive, whitespace matters).

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. List any four properties of a good hash function.
2. Generate SHA-1, and SHA-256 hashes for the string "NETWORK SECURITY" using CrypTool.
3. Compare outputs of MD5 and SHA-256 for the same message.
4. Design a simple program (in Python/C) to compute SHA-256 hash of user input and verify integrity.

Space for Answer

……………………………………………………………………………………………….......

……………………………………………………………………………………………….......

……………………………………………………………………………………………….......

XI. Exercise

1. Demonstrate avalanche effect by computing SHA-256 hash of HELLO and HELLo.
2. Compare hash outputs using CrypTool and online generators.
3. Research and report on MD-5 algorithm.

XII. References / Suggestions for further reading

1. Stallings, W. Cryptography and Network Security: Principles and Practice.
2. Kahate, A. Cryptography and Network Security.
3. NPTEL Course: Introduction to Cryptography and Network Security.
4. CrypTool Official Website: https://www.cryptool.org
5. Virtual Labs, IIIT Hyderabad, n.d. Cryptography Experiments. Available at: https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html

XIII. Assessment schemes

Performance Indicators		**Weightage**
Process related (15 Marks)		**60 %**
1	Correct generation of hash values using CrypTool	20 %
2	Verification of integrity using hash values	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Correctness of hash outputs	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 10: i. Write a C program to implement Diffie-Hellman key exchange algorithm to perform encryption of text
ii. Use Diffie-Hellman key exchange algorithm to perform encryption and decryption of text using any open-source tool (Example - Cryptool)

I. Practical Significance

This practical introduces the Diffie-Hellman key exchange protocol, the first widely used public key exchange method. It allows two parties to establish a shared secret key over an insecure channel without transmitting the key itself. This secret key can then be used for symmetric encryption. Students will implement the algorithm in C and apply it using CrypTool to understand how secure key exchange is achieved in real-world cryptography.

II. Industry / Employer Expected Outcome

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO4 – Use tools and techniques to prevent cyber attacks.

IV. Laboratory Learning Outcome (LLO)

LLO 10.1: Implement Diffie-Hellman key exchange encryption technique.

V. Relevant Affective domain related Outcomes(s)

1. Ethical awareness: Understanding that secure key management is essential for data privacy.
2. Analytical skills: Evaluating modular arithmetic and prime number role in cryptography.
3. Attention to detail: Correct implementation of exponentiation and modular operations.

I. Theoretical Background

Diffie–Hellman Key Exchange (DHKE):
The Diffie–Hellman Key Exchange (DHKE) is a method in cryptography that allows two parties to securely establish a shared secret key over an insecure communication channel. This shared key can then be used to encrypt further communications.
It was introduced in 1976 by Whitfield Diffie and Martin Hellman, and is considered one of the first practical implementations of public key cryptography.
The DH algorithm is based on the difficulty of the **Discrete Logarithm Problem (DLP)** in modular arithmetic.

1. Two parties (say **A** and **B**) agree on public parameters:
   - o A large **prime number** p
   - o A **primitive root** (or generator) g modulo p

These values (p,g)(p, g)(p,g) are **publicly known**.

2. Each party chooses a **private key**:

- Alice chooses a (secret)
- Bob chooses b (secret)

3. Each computes a **public key**:

- Alice computes $A = g^a \; mod \; p$
- Bob computes $B = g^b \; mod \; p$

Then they exchange these values.

4. Each party computes the **shared secret**:

- Alice computes $S = B^a \; mod \; p$
- Bob computes $S = A^b \; mod \; p$

Both values are mathematically equal:

$$S = g^{ab} \; mod \; p$$

5. Now, both Alice and Bob have the **same secret key S**, without ever sending it directly.

Example (Small Numbers for Simplicity)

1. Public parameters:

- Prime p=23
- Generator g=5

2. Private keys:

- Alice chooses a=6
- Bob chooses b=15

3. Public keys:

- Alice computes: $A = g^a \; mod \; p = 5^6 \; mod \; 23 = 15625 \; mod \; 23 = 8$
- Bob computes: $B = g^b \; mod \; p = \; 5^{15} \; mod \; 23 = \; 30517578125 \; mod \; 23 = 19$
- So Alice sends **8**, Bob sends **19**.

4. Shared secret:

- Alice computes: $S = B^a \; mod \; p = \; 19^6 \; mod \; 23 = \; 47045881 \; mod \; 23 = 2$
- Bob computes: $S = A^b \; mod \; p$ = $8^{15} \; mod \; 23 = \; 35184372088832 \; mod \; 23 = 2$
- Both Alice and Bob now share the secret key **2**, which can be used for encryption.

II. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows XP / 7 onwards / LINUX V 5.0 or latest		
3	Tools / Software Required	Turbo C Compiler, CrypTool 1.4.42		

III. Procedure

Diffie–Hellman Key Exchange (DHKE): Implementation using C program

Step 1: START

Step 2: Declare variables

- int p // large prime modulus
- int g // primitive root (generator) modulo p
- int a, b // private keys (chosen by Alice and Bob respectively)
- int A, B // public keys (A = g^a mod p, B = g^b mod p)
- int s1, s2 // shared secrets computed by Alice and Bob

Step 3: Implement helper function modularExponentiation(base, exp, mod)

- Input: base, exp, mod
- Output: (base^exp) % mod computed efficiently using binary (fast) exponentiation
- Pseudocode for helper:

```
1.  result <- 1
2.  base <- base % mod
3.  while exp > 0 do
a. if (exp % 2 == 1) then result <- (result * base) % mod
b. exp <- exp / 2 (integer division)
c. base <- (base * base) % mod
4.        return result
```

Step 4: Input or set public parameters p and g

- Option A: Prompt user to enter a prime p and generator g
- Option B: Use example/standard values for demonstration (ensure p is prime and g is a primitive root mod p)

Step 5: Alice chooses private key a (random integer, 1 < a < p-1)

Step 6: Bob chooses private key b (random integer, 1 < b < p-1)

Step 7: Alice computes her public key A

- A <- modularExponentiation(g, a, p)

Step 8: Bob computes his public key B

- B <- modularExponentiation(g, b, p)

Step 9: Alice sends A to Bob; Bob sends B to Alice (over insecure channel)

Step 10: Alice computes shared secret s1 using Bob's public key

- s1 <- modularExponentiation(B, a, p)

Step 11: Bob computes shared secret s2 using Alice's public key

- s2 <- modularExponentiation(A, b, p)

Step 12: Verify shared secret equality

- If s1 == s2 then

a. Shared secret established: shared_secret <- s1

b. Else: error — keys do not match

Step 13: Display values (optional / for demonstration):

- Show p, g, a (private of Alice — usually not displayed), b (private of Bob — not displayed), A, B, and shared_secret

Step 14: STOP

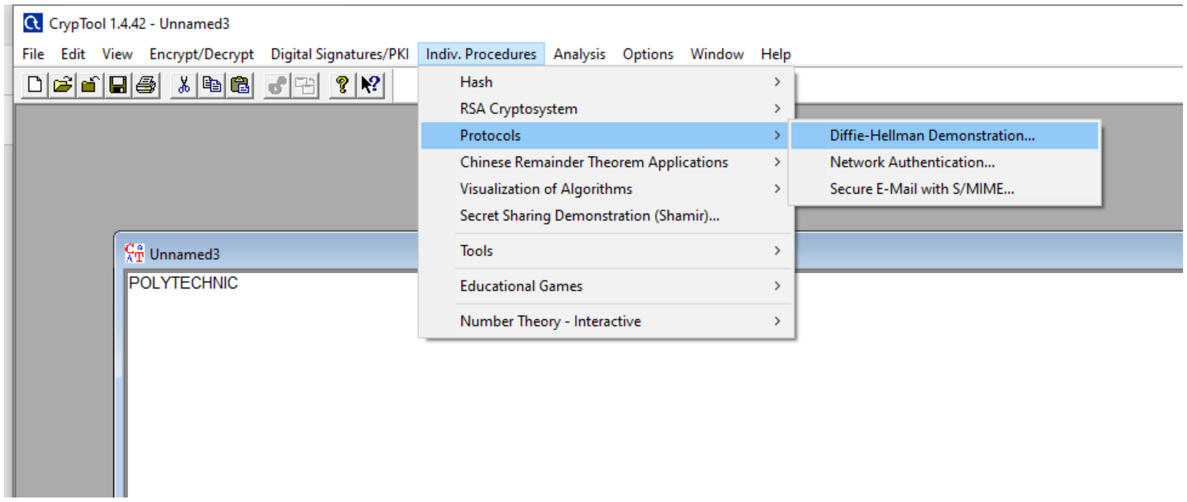
Diffie–Hellman Key Exchange (DHKE) using CrypTool 1.4.42

Step 1: START

Algorithm / Steps:

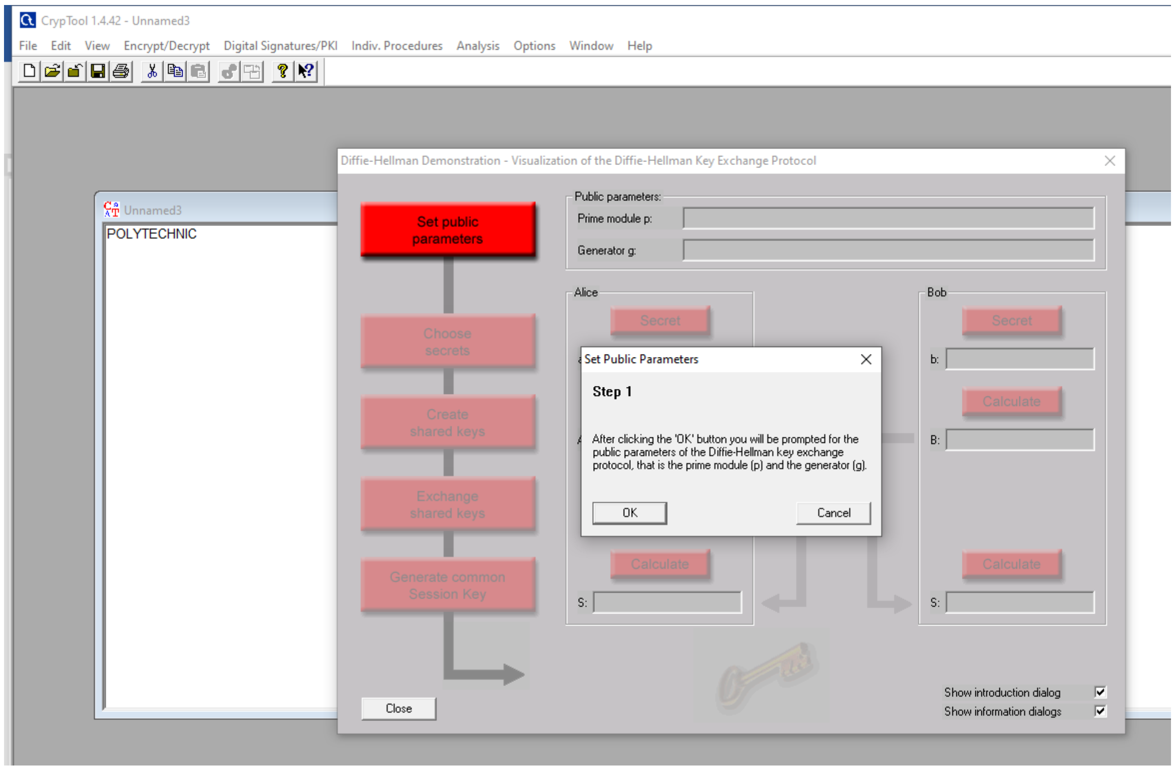
Step 1: Open CrypTool 1.4.2.

Step 2:From the menu, select Indiv. Procedures → Protocols → Diffie-Hellman Demonstration.


CrypTool 1.4.42 - Unnamed3
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
Hash
RSA Cryptosystem
Protocols
Chinese Remainder Theorem Applications
Visualization of Algorithms
Secret Sharing Demonstration (Shamir)...
Tools
Educational Games
Number Theory - Interactive
Diffie-Hellman Demonstration...
Network Authentication...
Secure E-Mail with S/MIME...
Unnamed3
POLYTECHNIC

Step 3: Set public parameters:

- ○ Generate a large prime number (p) and accept it.
- ○ Generate a generator (g) and accept it.
- ○ Both p and g are public.



Set Public Parameters

Step 1

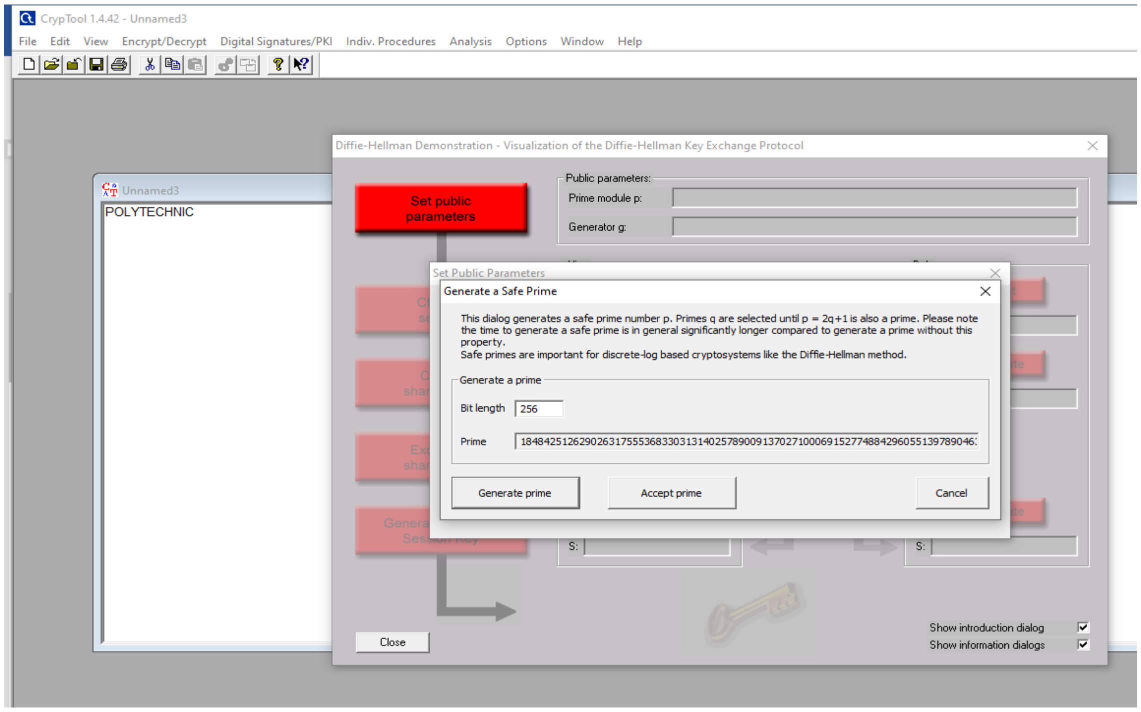
After clicking the 'OK' button you will be prompted for the public parameters of the Diffie-Hellman key exchange protocol, that is the prime module (p) and the generator (g).

OK Cancel

Step 4: Choose secrets:

- ○ Alice selects a private number a.

- Bob selects a private number b.
- Both values remain hidden.


CrypTool 1.4.42 - Unnamed3
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
Unnamed3
POLYTECHNIC
Diffie-Hellman Demonstration - Visualization of the Diffie-Hellman Key Exchange Protocol
Set public parameters
Public parameters:
Prime module p:
Generator g:
Set Public Parameters
S:
S:
Close
Show introduction dialog
Show information dialogs

Generate a Safe Prime

This dialog generates a safe prime number p. Primes q are selected until p = 2q+1 is also a prime. Please note the time to generate a safe prime is in general significantly longer compared to generate a prime without this property.
Safe primes are important for discrete-log based cryptosystems like the Diffie-Hellman method.

Generate a prime

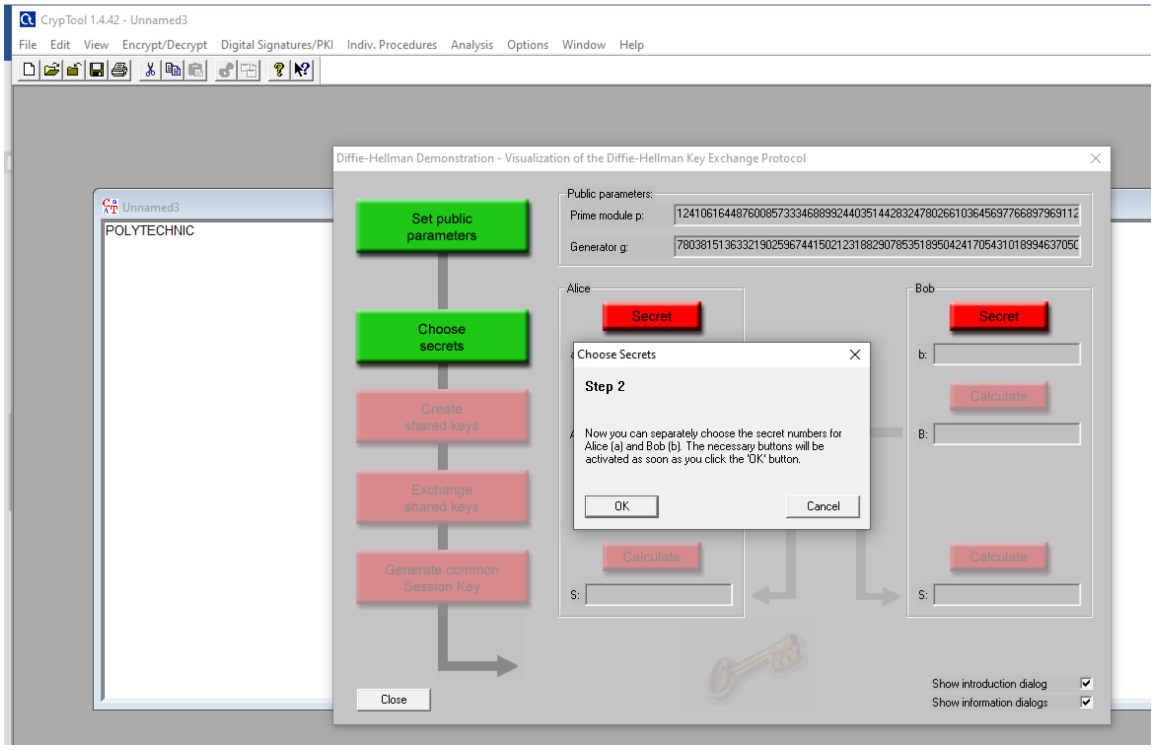
Bit length: 256

Prime: 18484251262902631755536833031314025789009137027100069152774884296055139789046

Generate prime | Accept prime | Cancel

Step 5: Create shared keys (public values):

- Alice computes A = g^a mod p.
- Bob computes B = g^b mod p.


CrypTool 1.4.42 - Unnamed3
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
Unnamed3
POLYTECHNIC
Diffie-Hellman Demonstration - Visualization of the Diffie-Hellman Key Exchange Protocol
Set public parameters
Choose secrets
Create shared keys
Exchange shared keys
Generate common Session Key
Alice
Bob
Secret
Secret
b:
Calculate
B:
Calculate
Calculate
S:
S:
Close
Show introduction dialog
Show information dialogs

Public parameters:

Prime module p: 124106164487600857333468899244035144283247802661036456977668979691 12

Generator g: 780381513633219025967441502123188290785351895042417054310189946370 5

Choose Secrets

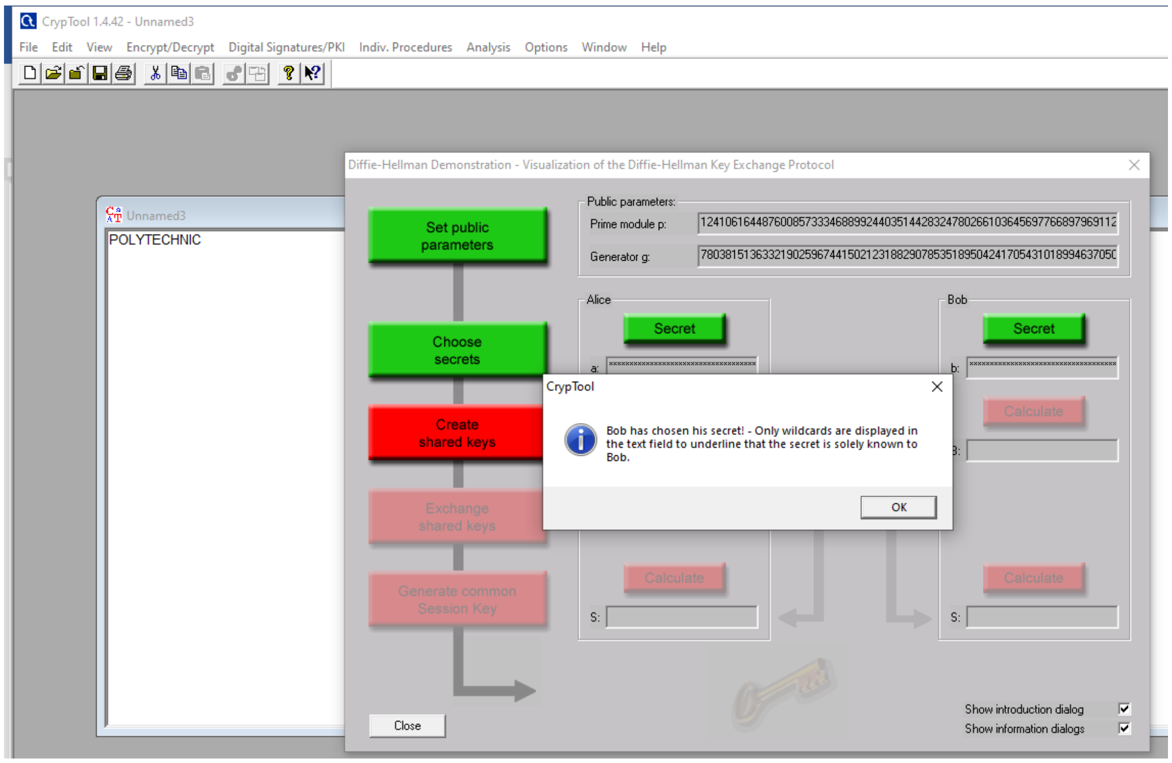
Step 2

Now you can separately choose the secret numbers for Alice (a) and Bob (b). The necessary buttons will be activated as soon as you click the 'OK' button.

OK | Cancel

Step 6: Exchange keys:

- Alice sends A to Bob.
- Bob sends B to Alice.


CrypTool 1.4.42 - Unnamed3
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
Unnamed3
Diffie-Hellman Demonstration - Visualization of the Diffie-Hellman Key Exchange Protocol
Set public parameters
Choose secrets
Create shared keys
Exchange shared keys
Generate common Session Key
Close
Alice
Secret
Bob
Secret
Calculate
Calculate
Calculate
S:
S:
CrypTool
OK

POLYTECHNIC

Public parameters:
Prime module p: 12410616448760085733346889924403514428324780266103645697766897969112
Generator g: 78038151363321902596744150212318829078535189504241705431018994637050

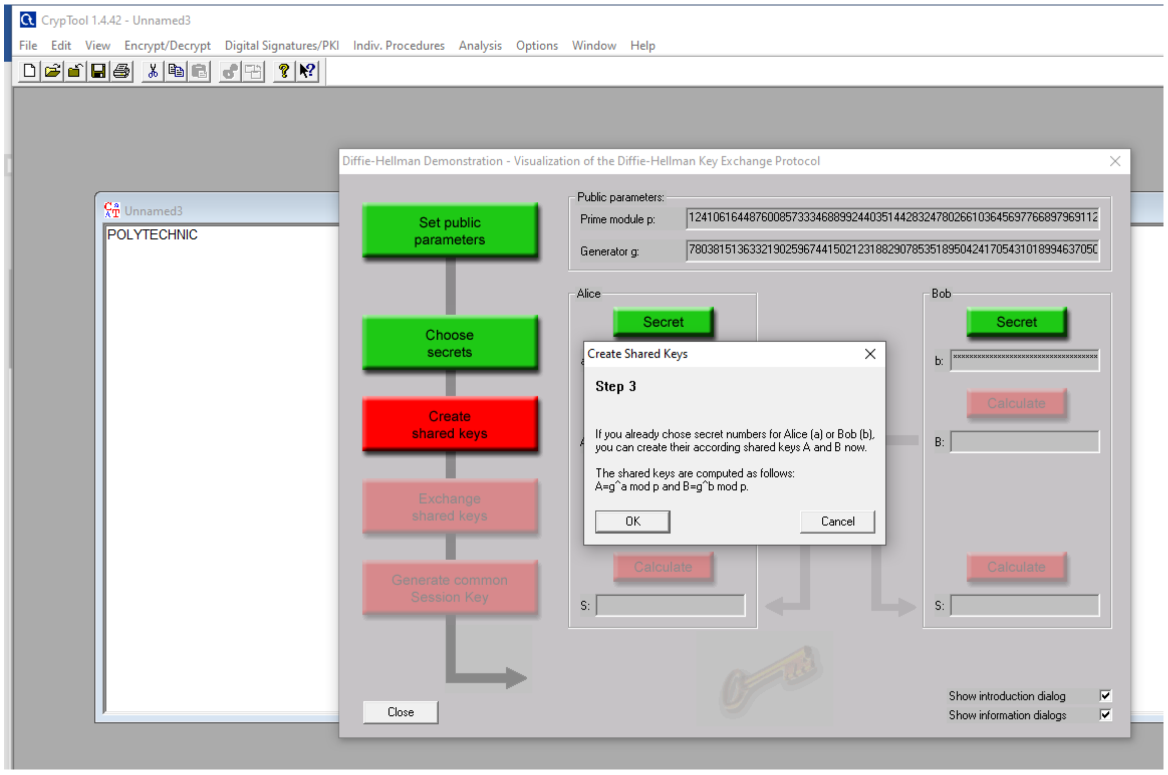
a: ***********************************
b: ***********************************

Bob has chosen his secret! - Only wildcards are displayed in the text field to underline that the secret is solely known to Bob.

Show introduction dialog ☑
Show information dialogs ☑

Step 7: Generate session key:

- Alice computes S = B^a mod p.
- Bob computes S = A^b mod p.
- Both values are identical.


CrypTool 1.4.42 - Unnamed3
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
Unnamed3
Diffie-Hellman Demonstration - Visualization of the Diffie-Hellman Key Exchange Protocol
Set public parameters
Choose secrets
Create shared keys
Exchange shared keys
Generate common Session Key
Close
Alice
Secret
Bob
Secret
Calculate
Calculate
Calculate
B:
S:
S:
Create Shared Keys
OK
Cancel

POLYTECHNIC

Public parameters:
Prime module p: 12410616448760085733346889924403514428324780266103645697766897969112
Generator g: 78038151363321902596744150212318829078535189504241705431018994637050

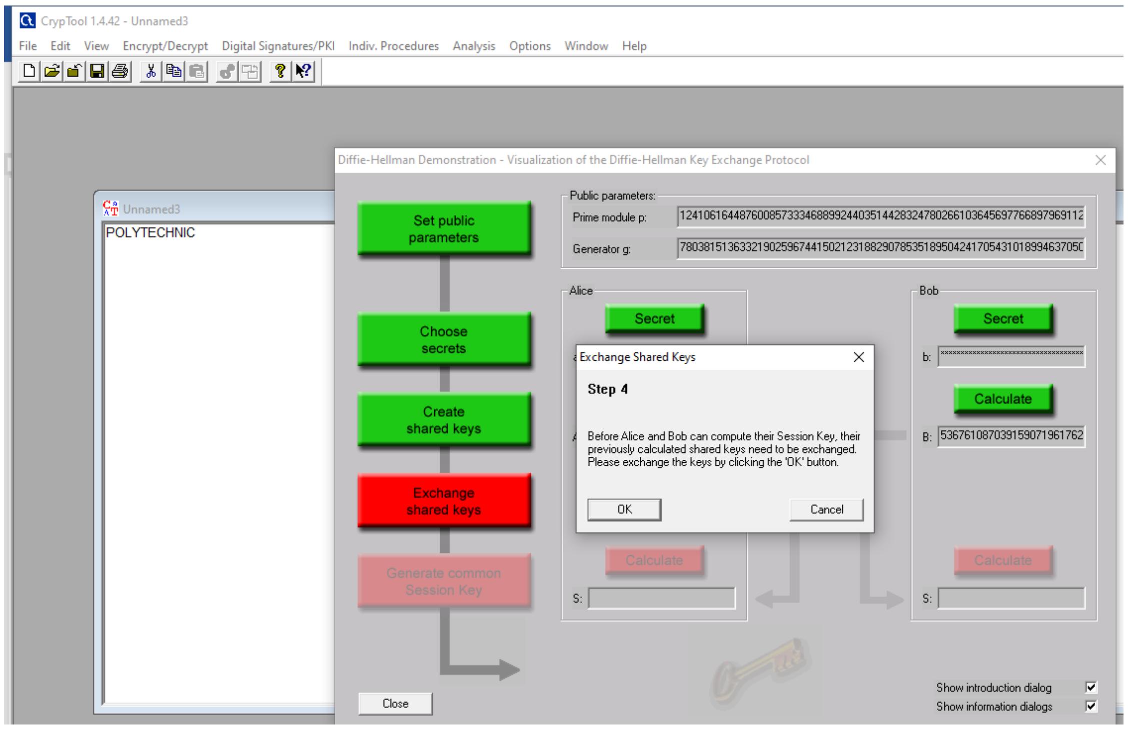
b: ***********************************

Step 3

If you already chose secret numbers for Alice (a) or Bob (b), you can create their according shared keys A and B now.

The shared keys are computed as follows:
A=g^a mod p and B=g^b mod p.

Show introduction dialog ☑
Show information dialogs ☑


CrypTool 1.4.42 - Unnamed3
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
Unnamed3
Diffie-Hellman Demonstration - Visualization of the Diffie-Hellman Key Exchange Protocol
Set public parameters
Choose secrets
Create shared keys
Exchange shared keys
Generate common Session Key
Close
Alice
Bob
Secret
Calculate
Show introduction dialog
Show information dialogs

POLYTECHNIC

Public parameters:
Prime module p: 12410616448760085733346889924403514428324780266103645697766897969112
Generator g: 78038151363321902596744150212318829078535189504241705431018994637050

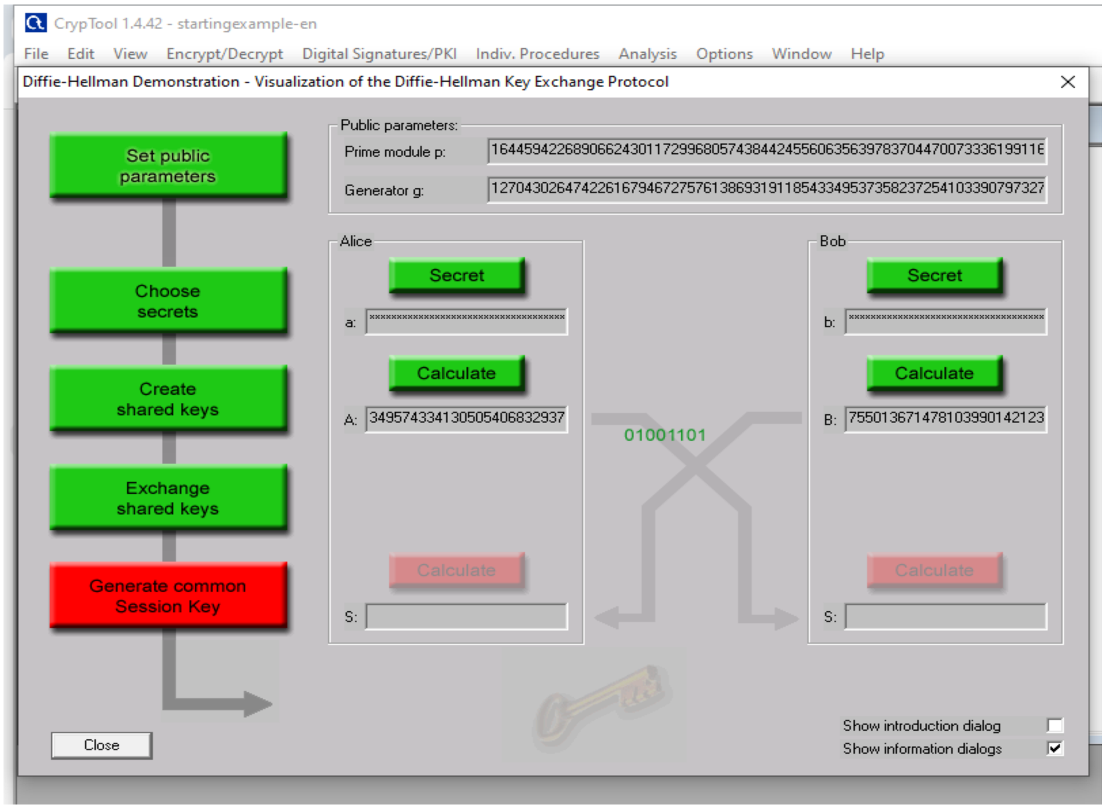
b: ***********************************
B: 536761087039159071961762
S:

Exchange Shared Keys

Step 4

Before Alice and Bob can compute their Session Key, their previously calculated shared keys need to be exchanged. Please exchange the keys by clicking the 'OK' button.

OK Cancel

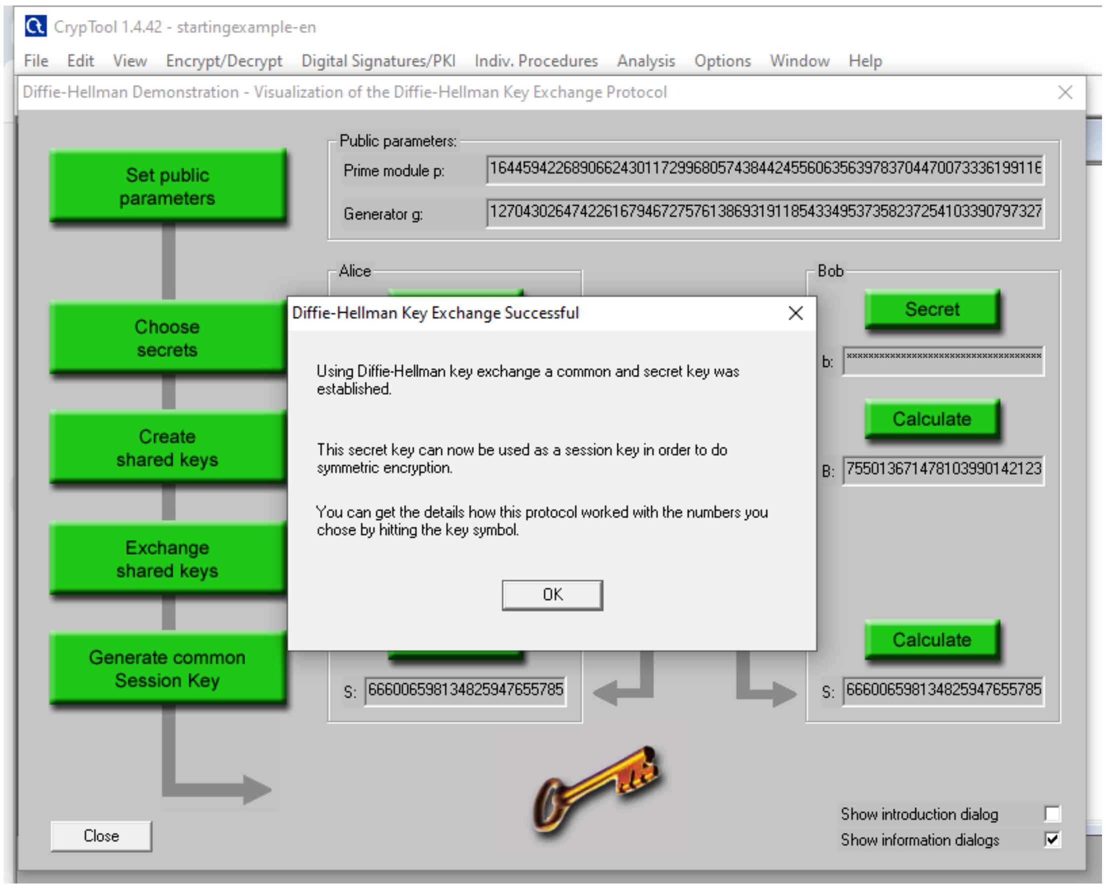

CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
Diffie-Hellman Demonstration - Visualization of the Diffie-Hellman Key Exchange Protocol
Set public parameters
Choose secrets
Create shared keys
Exchange shared keys
Generate common Session Key
Alice
Bob
Secret
Calculate
01001101
Close
Show introduction dialog
Show information dialogs

Public parameters:
Prime module p: 16445942268906624301172996805743844245560635639783704470073336199116
Generator g: 12704302647422616794672757613869319118543349537358237254103390797327

a: ***********************************
A: 349574334130505406832937
b: ***********************************
B: 755013671478103990142123
S:
S:

Show introduction dialog ☐
Show information dialogs ☑

Step 8:Verify: CrypTool displays the same session key for Alice and Bob → key exchange successful.


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
Set public parameters
Choose secrets
Create shared keys
Exchange shared keys
Generate common Session Key
Secret
Calculate
OK
Close

Diffie-Hellman Demonstration - Visualization of the Diffie-Hellman Key Exchange Protocol

Public parameters:
Prime module p: 16445942268906624301172996805743844245560635639783704470073336199116
Generator g: 12704302647422616794672757613869319118543349537358237254103390797327

Alice
S: 666006598134825947655785

Bob
b: ************************************
B: 7550136714781039901421 23
S: 6660065981348259476557 85

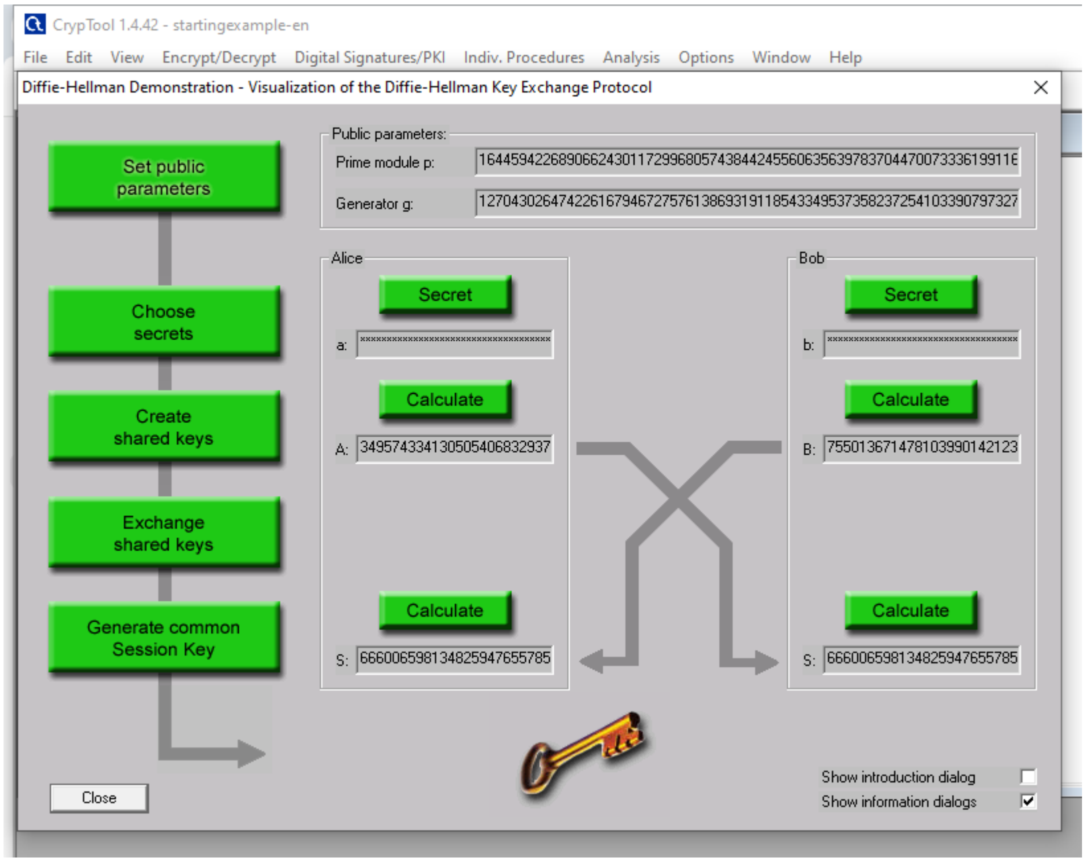
Diffie-Hellman Key Exchange Successful

Using Diffie-Hellman key exchange a common and secret key was established.

This secret key can now be used as a session key in order to do symmetric encryption.

You can get the details how this protocol worked with the numbers you chose by hitting the key symbol.

Show introduction dialog ☐
Show information dialogs ☑


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
Set public parameters
Choose secrets
Create shared keys
Exchange shared keys
Generate common Session Key
Secret
Calculate
Close

Diffie-Hellman Demonstration - Visualization of the Diffie-Hellman Key Exchange Protocol

Public parameters:
Prime module p: 16445942268906624301172996805743844245560635639783704470073336199116
Generator g: 12704302647422616794672757613869319118543349537358237254103390797327

Alice
a: ************************************
A: 349574334130505406832937
S: 666006598134825947655785

Bob
b: ************************************
B: 755013671478103990142123
S: 666006598134825947655785

Show introduction dialog ☐
Show information dialogs ☑

A common secret session key S shared by both Alice and Bob.

IV. Precautions

1. Key length must equal plaintext length.
2. Keys must remain secret and used only once.
3. Save test data to verify correctness.

V. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. State the encryption and decryption formulas for Vernam cipher.
2. Differentiate between Caesar cipher and Vernam cipher.
3. Encrypt your name using CrypTool with Vernam cipher and attach a screenshot.
4. Implement Vernam cipher to encrypt the string "NETWORK"

Space for Answer

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VI. Exercise

1. Modify the C program to accept keys in binary format.
2. Demonstrate encryption of a paragraph of text using Vernam cipher..
3. Compare Vernam cipher with modern stream ciphers (RC4, Salsa20).

VII. References / Suggestions for further reading

1. Stallings, W. Cryptography and Network Security: Principles and Practice.
2. Kahate, A. Cryptography and Network Security.
3. CrypTool Official Website: https://www.cryptool.org
4. NPTEL Course: Introduction to Cryptography and Network Security.
5. Virtual Labs, IIIT Hyderabad, n.d. Cryptography Experiments. Available at: https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html

VIII. Assessment schemes

Performance Indicators		**Weightage**
Process related (15 Marks)		**60 %**
1	Correct implementation of Vernam cipher in C	20 %
2	Successful use of CrypTool for encryption/decryption	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Correctness of ciphertext and plaintext recovery	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 11: Use Steganography to encode and decode the message using any Open source tool (Example – OpenStego)

I. Practical Significance

This practical introduces steganography, a technique used to conceal information within another file such as an image, audio, or video so that the existence of the hidden data remains undetectable.Students will learn to embed (encode) and extract (decode) a secret message using OpenStego, an open-source tool for digital data hiding.The aim is to understand the concept of data confidentiality and covert communication.

II. Industry / Employer Expected Outcome

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO4 – Use tools and techniques to prevent cyber attacks.

IV. Laboratory Learning Outcome (LLO)

LLO 11.1: Implement steganography.

V. Relevant Affective domain related Outcomes(s)

1. Responsibility: Apply tools properly to protect information confidentiality.
2. Ethical Awareness: Understand ethical use of steganography in secure systems.
3. Analytical Skills: Analyze and verify the integrity of extracted hidden messages.

VI. Theoretical Background

Steganography is the art and science of **embedding secret messages in a cover message** in such a way that no one, apart from the sender and intended recipient, suspects the existence of the message. It conceals the fact that communication is taking place, providing an additional layer of security beyond traditional cryptography.

As the image depicts, both the **cover file (X)** and **secret message (M)** are fed into a **Steganographic Encoder** as inputs.

The **Steganographic Encoder function**, represented as **f(X, M, K)**, embeds the secret message into the cover file using a key **K**.The resulting **Stego Object** looks very similar to the original cover file, with **no visible changes**, thereby concealing the hidden data.This completes the **encoding** process.To retrieve the hidden message, the **Stego Object** is fed into a **Steganographic Decoder**, which extracts the original secret message **M** using the same key **K**.

In simpler terms, steganography hides the **existence of information**, whereas **cryptography** hides the **meaning of information**.

Common Steganographic Media:

- **Image files** (e.g., .bmp, .png)
- **Audio files** (e.g., .wav, .mp3)
- **Video files** (e.g., .mp4, .avi)

OpenStego is an open-source tool that provides two major functionalities:

1. **Data Hiding (Message Embedding)**
2. **Watermarking (Authentication)**

Applications:

- Secure and covert communication
- Digital watermarking for copyright protection
- Data confidentiality in sensitive communications

VII. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows XP / 7 onwards / LINUX V 5.0 or latest		
3	Tools / Software Required	CrypTool 1.4.42		

VIII. Procedure

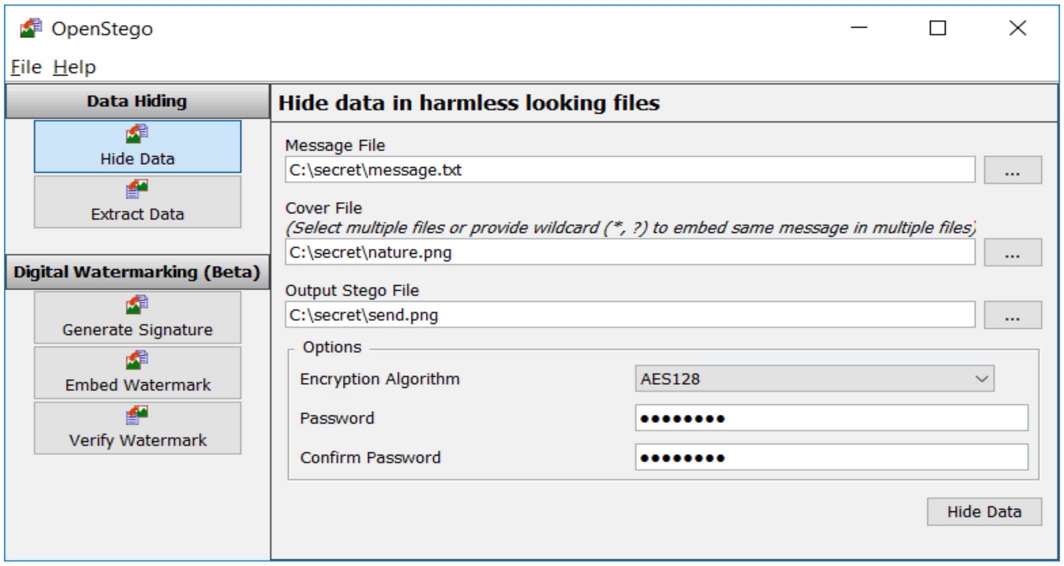
Step-by-Step Procedure

Step 1: Download and Install OpenStego

- OpenStego is available for multiple operating systems such as **Windows**, **Linux**, and **macOS**.
- Visit the official website: https://www.openstego.com
- Download the version compatible with your operating system.
- Follow the installation instructions to install OpenStego on your computer.

Step 2: Launch OpenStego

- After successful installation, **launch** the OpenStego application.
- The main interface window will appear.



Message File: C:\secret\message.txt

Cover File (Select multiple files or provide wildcard (*, ?) to embed same message in multiple files): C:\secret\nature.png

Output Stego File: C:\secret\send.png

Options

Encryption Algorithm: AES128

Password: ••••••••

Confirm Password: ••••••••

Step 3: Select the File to Embed Data

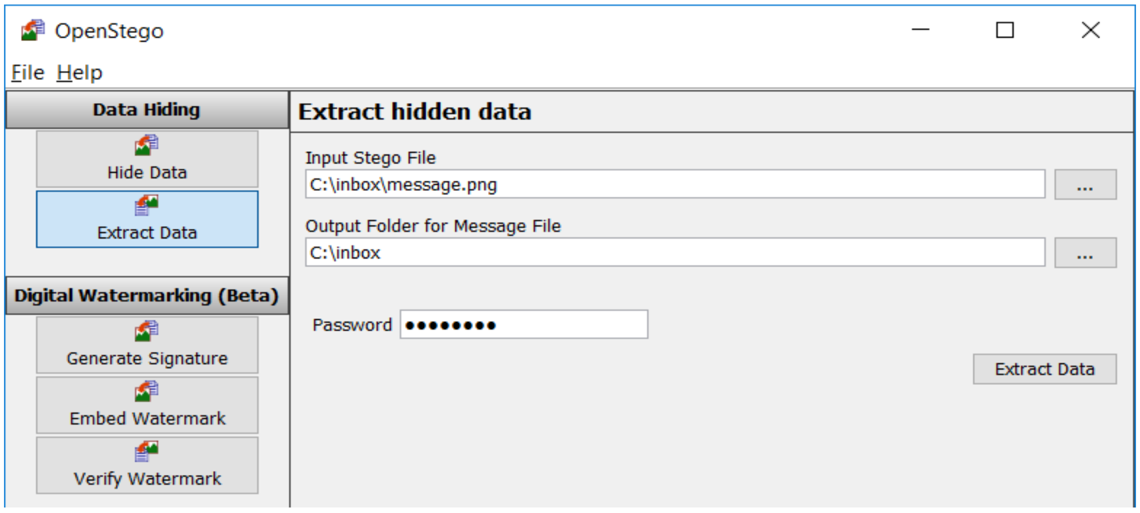
- Click on the **"Embed"** option in the OpenStego interface.
- Under the "Cover File" section, **browse and select** the file in which you want to embed (hide) your data.
- This file is known as the **carrier** or **cover object**.

Step 4: Select the Data to Embed

- Under the "Message File" section, **browse and select** the file containing the **data to be hidden**.
- OpenStego supports embedding various file types such as **text files, images, and other data files**.

Step 5: Configure Encryption Settings

- OpenStego provides **encryption and password protection options** to secure hidden data.
- Enter a **password/key** for encryption or configure other settings as required.
- You may also specify the **output file name** and location where the stego file will be saved.



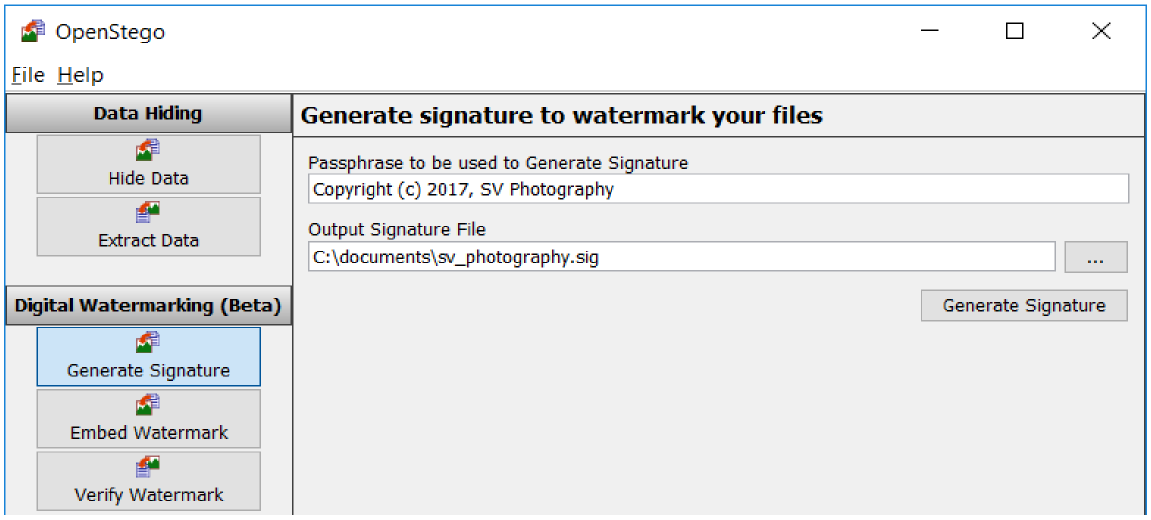
Input Stego File: C:\inbox\message.png

Output Folder for Message File: C:\inbox

Password: ••••••••

Step 6: Embed the Data

- After configuration, click the **"Embed"** button.
- OpenStego will process the files and generate a **new stego file** that contains the hidden data.
- A confirmation message will appear once the embedding process is completed successfully.



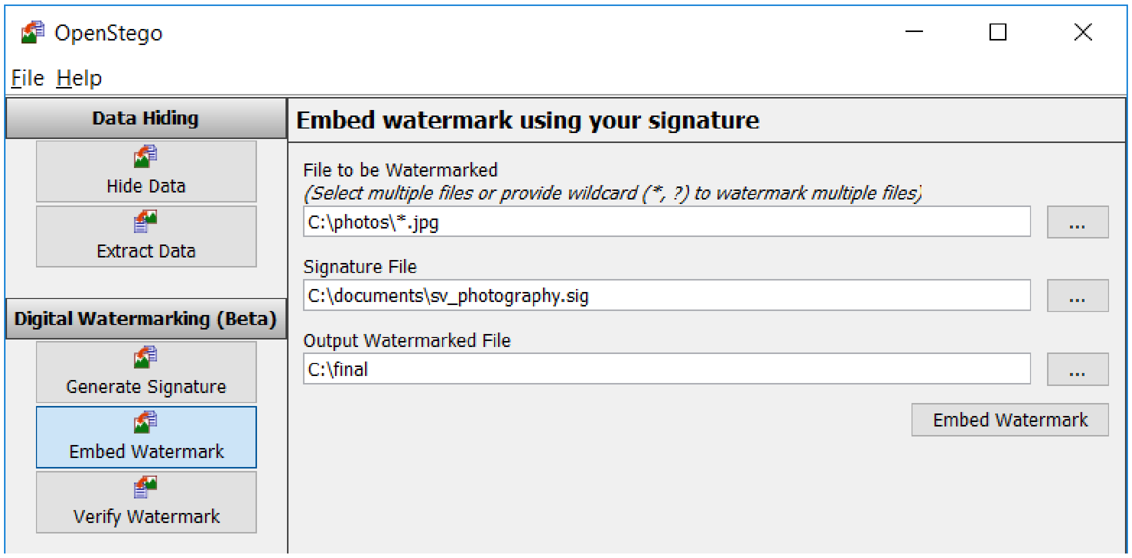
Generate signature to watermark your files

Passphrase to be used to Generate Signature
Copyright (c) 2017, SV Photography

Output Signature File
C:\documents\sv_photography.sig

Step 7: Extract the Hidden Data

- To retrieve the hidden data, go back to the main screen and click the **“Extract”** button.
- In the extraction window:
  - Select the **stego file** (the one that contains the hidden data).
  - Specify the **output location** where extracted data will be saved.
- Click **“Extract”** to begin the extraction process.



Embed watermark using your signature

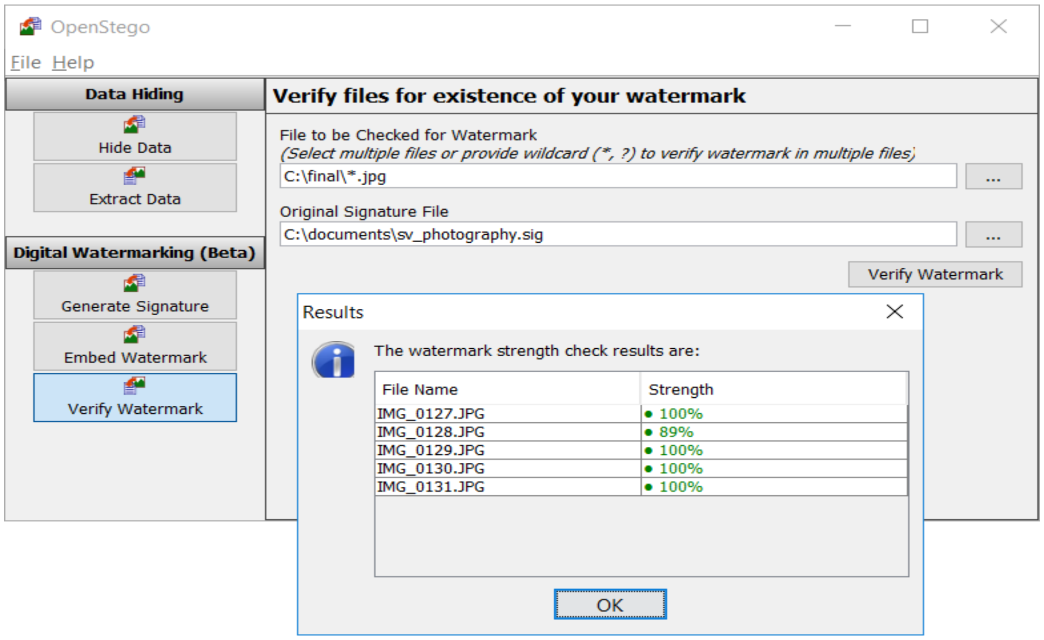
File to be Watermarked
(Select multiple files or provide wildcard (*, ?) to watermark multiple files)
C:\photos\*.jpg

Signature File
C:\documents\sv_photography.sig

Output Watermarked File
C:\final

Step 8: View Extracted Data

- Once extraction is complete, OpenStego will save the **recovered hidden file** in the specified folder.
- Open the extracted file to verify that the data has been retrieved successfully.



Verify files for existence of your watermark

File to be Checked for Watermark
(Select multiple files or provide wildcard (*, ?) to verify watermark in multiple files)
C:\final\*.jpg

Original Signature File
C:\documents\sv_photography.sig

Results

The watermark strength check results are:

File Name	Strength
IMG_0127.JPG	● 100%
IMG_0128.JPG	● 89%
IMG_0129.JPG	● 100%
IMG_0130.JPG	● 100%
IMG_0131.JPG	● 100%

IX. Precautions

1. Use high-quality image files (e.g., .png) for better embedding capacity.
2. Avoid compressing stego files after encoding (may damage hidden data).
3. Keep original and stego files secure and clearly labeled.
4. Do not share passwords or hidden data publicly.

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Describe steganography. How does it differ from cryptography?
2. Mention three common file formats used in steganography.
3. Explain the two main functions of OpenStego.
4. What precautions should be taken when using steganography tools?
5. Perform encoding and decoding using OpenStego and record your observations.

Space for Answer

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XI. Exercise

1. Encode and decode a message using OpenStego with different file formats (e.g., .bmp, .png).
2. Compare stego file sizes before and after embedding.
3. Research and report on the use of steganography in digital watermarking.

XII. References / Suggestions for further reading

1. Stallings, W. Cryptography and Network Security: Principles and Practice.
2. Kahate, A. Cryptography and Network Security.
3. NPTEL Course: Introduction to Cryptography and Network Security.
4. OpenStego Official Website: https://www.openstego.com
5. Virtual Labs (IIIT Hyderabad): https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html

XIII. Assessment schemes

Performance Indicators		Weightage
Process related (15 Marks)		**60 %**
1	Correct encoding (hiding) of message using OpenStego	20 %
2	Accurate decoding and retrieval of hidden message	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Correctness and clarity of hidden message	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			Dated Signature of Teacher
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 12: Create and verify Digital Signature using any Open-source tool (Example – CrypTool).

I. Practical Significance

This practical introduces the concept of digital signatures, a cryptographic technique used to ensure the authenticity, integrity, and non-repudiation of digital messages or documents. Students will learn how digital signatures work using public and private key pairs and practice creating and verifying digital signatures using open-source tools such as CrypTool.

II. Industry / Employer Expected Outcome

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO4 – Use tools and techniques to prevent cyber attacks.

IV. Laboratory Learning Outcome (LLO)

LLO 12.1: Generate digital signature.

V. Relevant Affective domain related Outcomes(s)

1. Responsibility: Correct use of cryptographic tools to ensure message authenticity.
2. Ethical Awareness: Understanding how digital signatures help prevent data forgery and impersonation.
3. Analytical Skills: Interpreting and validating digital signature verification outputs.

VI. Theoretical Background

A Digital Signature is a mathematical technique used to validate the authenticity, integrity, and non-repudiation of a message, software, or digital document. It provides a secure and verifiable way of confirming that a message originates from a verified sender and has not been altered during transmission.
Digital signatures are a crucial component of modern cryptographic communication systems and are widely used in secure email, software distribution, electronic transactions, and e-governance.
A digital signature uses public key cryptography (asymmetric encryption), which involves a private key and a public key:
The private key is known only to the sender and is used to create the signature.
The public key is shared with the receiver and is used to verify the signature.
A hash function is applied to the message to create a message digest, which is a fixed-length unique representation of the data. This digest is then encrypted using the sender's private key to form the digital signature.
At the receiver's end, the signature is decrypted using the sender's public key, and the resulting hash is compared with a newly computed hash of the received message. If both match, the message is verified as authentic and unaltered.

Structure of a Digital Signature Scheme

A digital signature scheme typically consists of **three core algorithms**:

1. **Key Generation Algorithm:**
   - Selects a **private key** uniformly at random from a set of possible keys.
   - Generates a corresponding **public key**.
   - Ensures both keys are mathematically linked but computationally infeasible to derive one from the other.
2. **Signing Algorithm:**
   - Generates a **one-way hash** of the message using a hashing function (e.g., SHA-256).
   - Encrypts this hash using the sender’s **private key** to produce a **digital signature**.
   - This signature, along with the message, is transmitted to the receiver.
3. **Verification Algorithm:**
   - The receiver decrypts the digital signature using the sender’s **public key** to retrieve the original hash.
   - The receiver computes a new hash from the received message using the same hash function.
   - If both hash values are identical, the message is **authentic** and **untampered**.

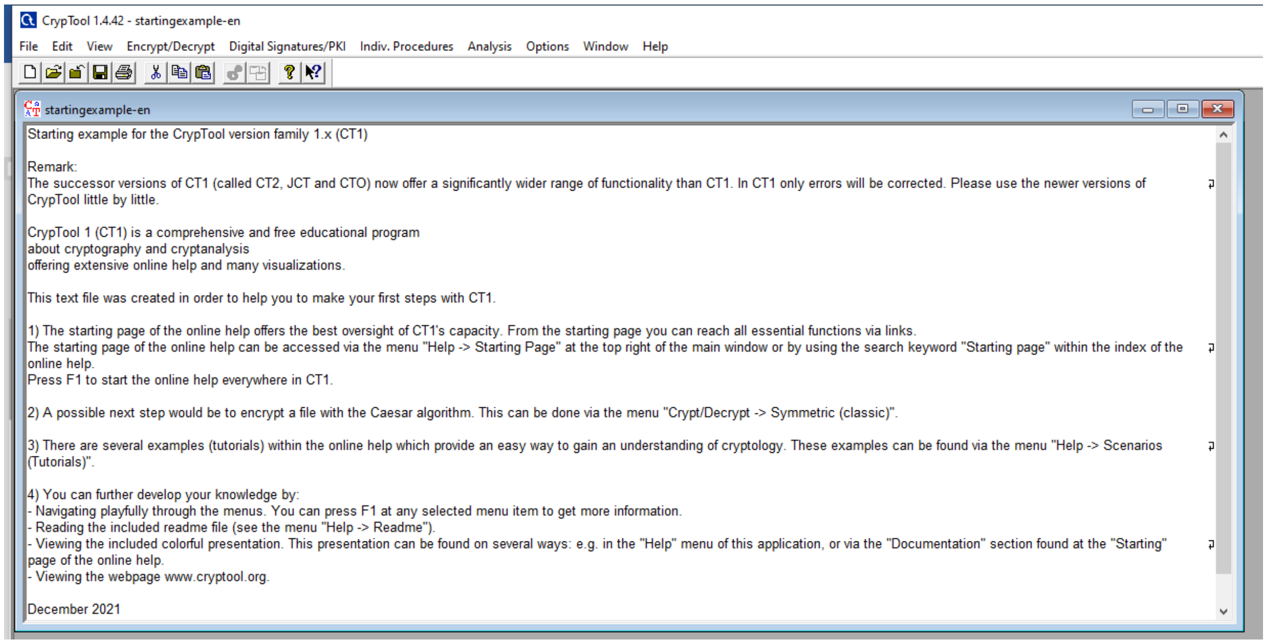
VII. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows XP / 7 onwards / LINUX V 5.0 or latest		
3	Tools / Software Required	CrypTool 1.4.42		

VIII. Procedure

Step-by-Step Procedure

Step 1. Create a new file or open an existing file.


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en

Starting example for the CrypTool version family 1.x (CT1)

Remark:
The successor versions of CT1 (called CT2, JCT and CTO) now offer a significantly wider range of functionality than CT1. In CT1 only errors will be corrected. Please use the newer versions of CrypTool little by little.

CrypTool 1 (CT1) is a comprehensive and free educational program
about cryptography and cryptanalysis
offering extensive online help and many visualizations.

This text file was created in order to help you to make your first steps with CT1.

1) The starting page of the online help offers the best oversight of CT1's capacity. From the starting page you can reach all essential functions via links.
The starting page of the online help can be accessed via the menu "Help -> Starting Page" at the top right of the main window or by using the search keyword "Starting page" within the index of the online help.
Press F1 to start the online help everywhere in CT1.

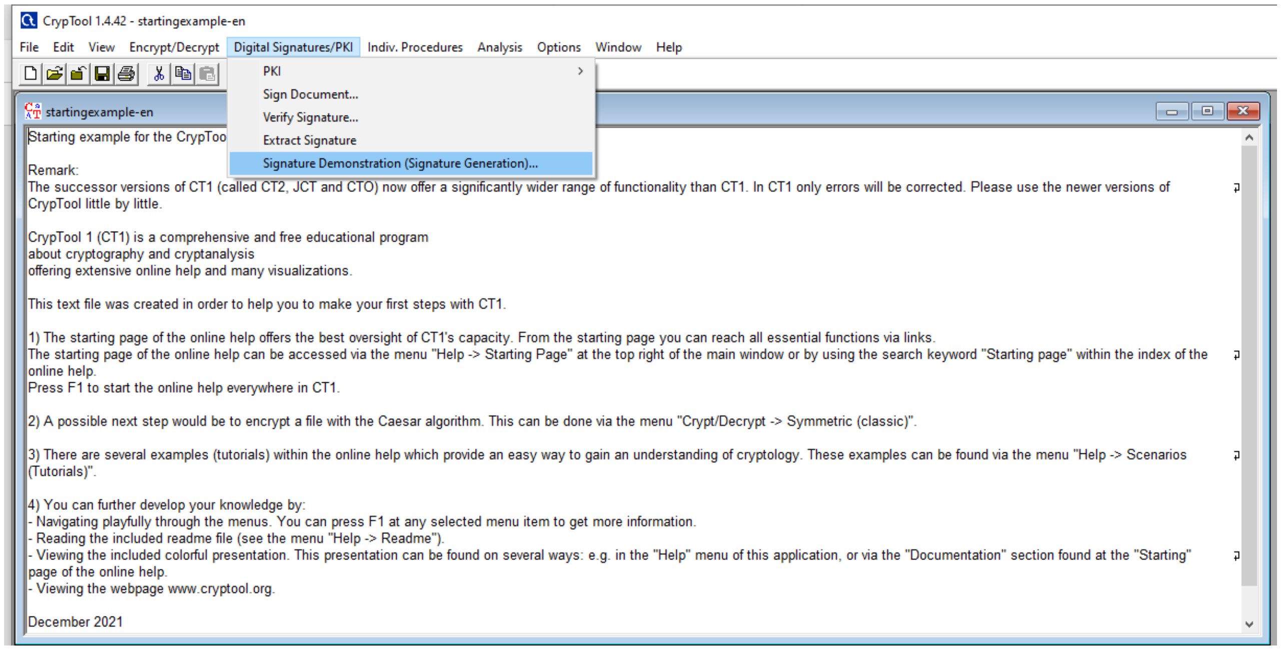
2) A possible next step would be to encrypt a file with the Caesar algorithm. This can be done via the menu "Crypt/Decrypt -> Symmetric (classic)".

3) There are several examples (tutorials) within the online help which provide an easy way to gain an understanding of cryptology. These examples can be found via the menu "Help -> Scenarios (Tutorials)".

4) You can further develop your knowledge by:
- Navigating playfully through the menus. You can press F1 at any selected menu item to get more information.
- Reading the included readme file (see the menu "Help -> Readme").
- Viewing the included colorful presentation. This presentation can be found on several ways: e.g. in the "Help" menu of this application, or via the "Documentation" section found at the "Starting" page of the online help.
- Viewing the webpage www.cryptool.org.

December 2021

Step 2. From the menu, select Digital Signature/PKI → Signature Demonstration.
The flow chart of the Digital Signature process will be displayed.


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
PKI
Sign Document...
Verify Signature...
Extract Signature
Signature Demonstration (Signature Generation)...
startingexample-en

Starting example for the CrypToo

Remark:
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- Viewing the webpage www.cryptool.org.

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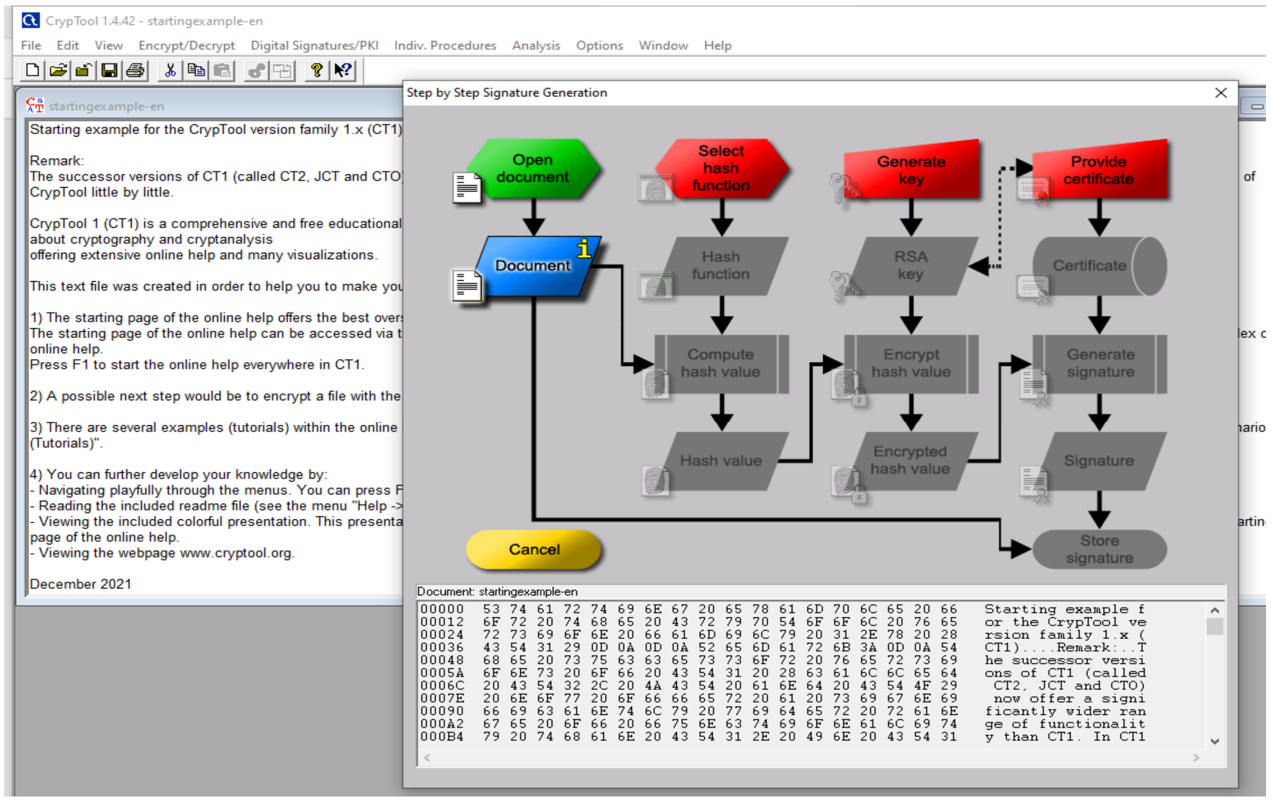
Step 3. Click on Select Hash Function and choose any hash function (e.g., MD5) as per your choice. Then click OK to confirm the selection.



Starting example for the CrypTool version family 1.x (CT1)

Remark:
The successor versions of CT1 (called CT2, JCT and CTO
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(Tutorials)".

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- Navigating playfully through the menus. You can press F
- Reading the included readme file (see the menu "Help ->
- Viewing the included colorful presentation. This presenta
page of the online help.
- Viewing the webpage www.cryptool.org.

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00000  53 74 61 72 74 69 6E 67 20 65 78 61 6D 70 6C 65 20 66   Starting example f
00012  6F 72 20 74 68 65 20 43 72 79 70 54 6F 6F 6C 20 76 65   or the CrypTool ve
00024  72 73 69 6F 6E 20 66 61 6D 69 6C 79 20 31 2E 78 20 28   rsion family 1.x (
00036  43 54 31 29 0D 0A 0D 0A 52 65 6D 61 72 6B 3A 0D 0A 54   CT1)....Remark:..T
00048  68 65 20 73 75 63 63 65 73 73 6F 72 20 76 65 72 73 69   he successor versi
0005A  6F 6E 73 20 6F 66 20 43 54 31 20 28 63 61 6C 6C 65 64   ons of CT1 (called
0006C  20 43 54 32 2C 20 4A 43 54 20 61 6E 64 20 43 54 4F 29    CT2, JCT and CTO)
0007E  20 6E 6F 77 20 6F 66 66 65 72 20 61 20 73 69 67 6E 69    now offer a signi
00090  66 69 63 61 6E 74 6C 79 20 77 69 64 65 72 20 72 61 6E   ficantly wider ran
000A2  67 65 20 6F 66 20 66 75 6E 63 74 69 6F 6E 61 6C 69 74   ge of functionalit
000B4  79 20 74 68 61 6E 20 43 54 31 2E 20 49 6E 20 43 54 31   y than CT1. In CT1
```
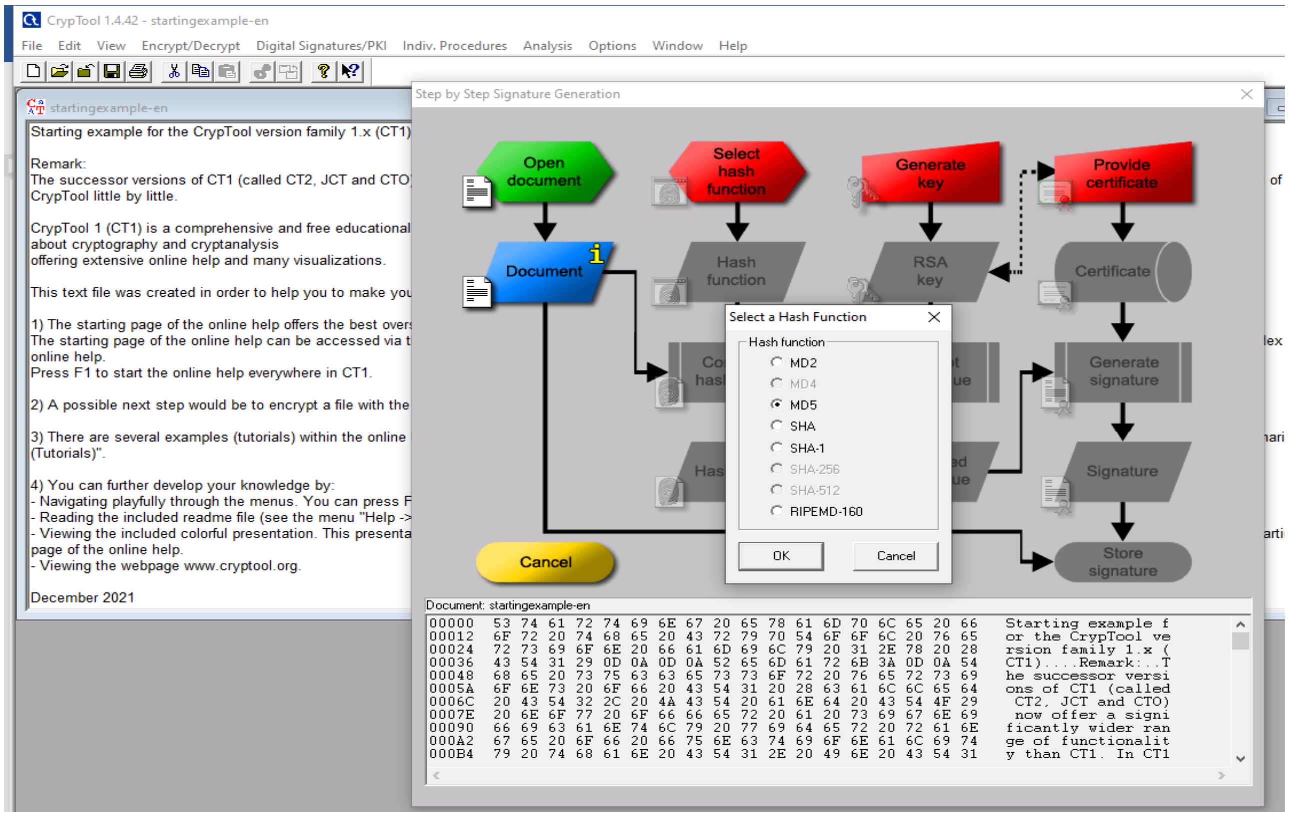

Step 4. Next, click on Generate Key.A Generate RSA Key window will appear. Click on Generate Prime.



Hash function
- MD2
- MD4
- [✓ MD5]
- SHA
- SHA-1
- SHA-256
- SHA-512
- RIPEMD-160

Starting example for the CrypTool version family 1.x (CT1)

Remark:
The successor versions of CT1 (called CT2, JCT and CTO
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- Navigating playfully through the menus. You can press F
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December 2021

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00000  53 74 61 72 74 69 6E 67 20 65 78 61 6D 70 6C 65 20 66   Starting example f
00012  6F 72 20 74 68 65 20 43 72 79 70 54 6F 6F 6C 20 76 65   or the CrypTool ve
00024  72 73 69 6F 6E 20 66 61 6D 69 6C 79 20 31 2E 78 20 28   rsion family 1.x (
00036  43 54 31 29 0D 0A 0D 0A 52 65 6D 61 72 6B 3A 0D 0A 54   CT1)....Remark:..T
00048  68 65 20 73 75 63 63 65 73 73 6F 72 20 76 65 72 73 69   he successor versi
0005A  6F 6E 73 20 6F 66 20 43 54 31 20 28 63 61 6C 6C 65 64   ons of CT1 (called
0006C  20 43 54 32 2C 20 4A 43 54 20 61 6E 64 20 43 54 4F 29    CT2, JCT and CTO)
0007E  20 6E 6F 77 20 6F 66 66 65 72 20 61 20 73 69 67 6E 69    now offer a signi
00090  66 69 63 61 6E 74 6C 79 20 77 69 64 65 72 20 72 61 6E   ficantly wider ran
000A2  67 65 20 6F 66 20 66 75 6E 63 74 69 6F 6E 61 6C 69 74   ge of functionalit
000B4  79 20 74 68 61 6E 20 43 54 31 2E 20 49 6E 20 43 54 31   y than CT1. In CT1
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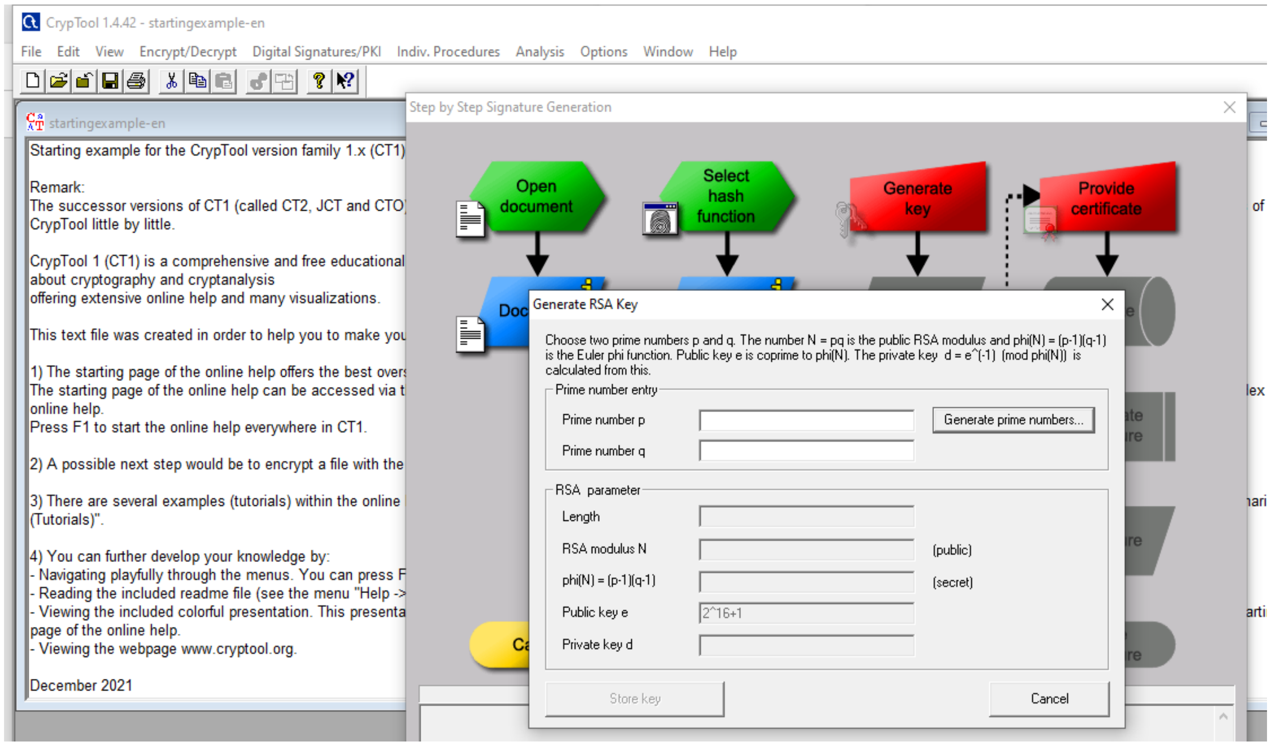
Step 5. Select the required options as shown in the demonstration interface.


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
Step by Step Signature Generation
Open document
Select hash function
Generate key
Provide certificate

Starting example for the CrypTool version family 1.x (CT1)

Remark:
The successor versions of CT1 (called CT2, JCT and CTO
CrypTool little by little.

CrypTool 1 (CT1) is a comprehensive and free educational
about cryptography and cryptanalysis
offering extensive online help and many visualizations.

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The starting page of the online help can be accessed via t
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Press F1 to start the online help everywhere in CT1.

2) A possible next step would be to encrypt a file with the

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- Reading the included readme file (see the menu "Help ->
- Viewing the included colorful presentation. This presenta
page of the online help.
- Viewing the webpage www.cryptool.org.

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Generate RSA Key

Choose two prime numbers p and q. The number N = pq is the public RSA modulus and phi(N) = (p-1)(q-1) is the Euler phi function. Public key e is coprime to phi(N). The private key d = e^(-1) (mod phi(N)) is calculated from this.

Prime number entry

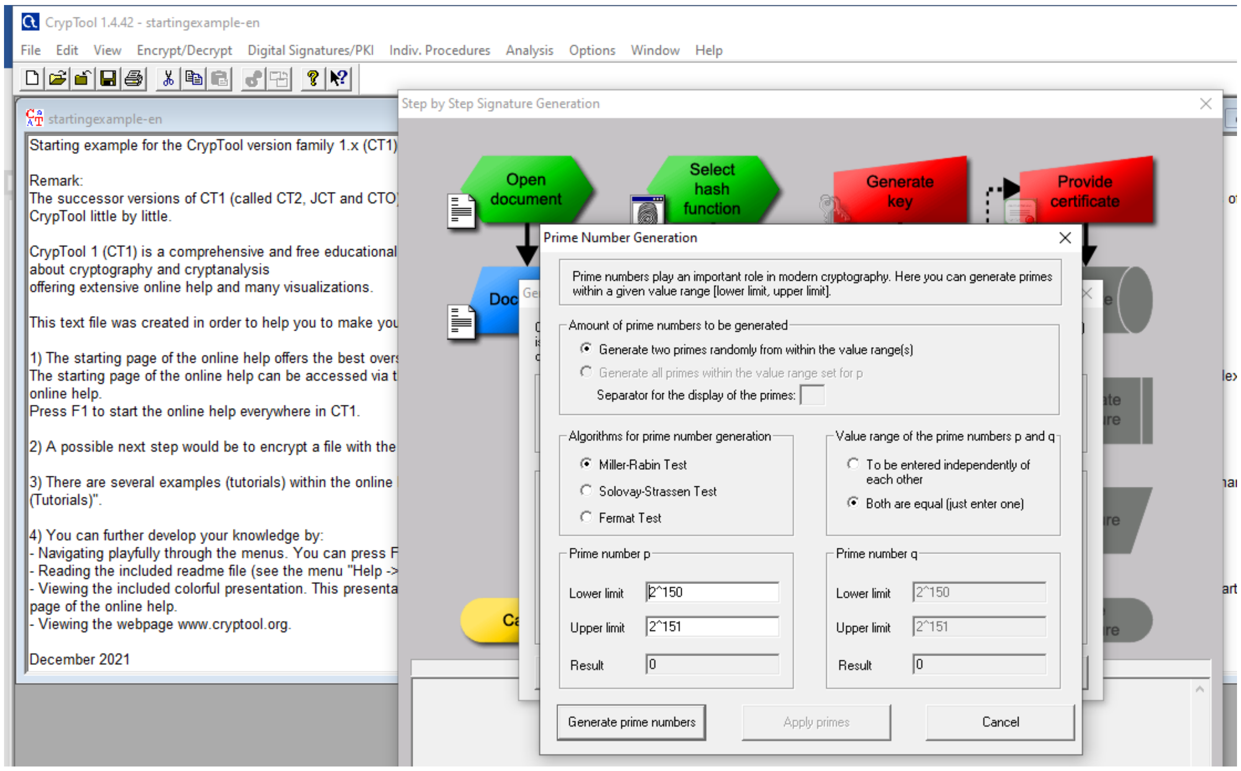
Prime number p		Generate prime numbers...
Prime number q		

RSA parameter

Length		
RSA modulus N		(public)
phi(N) = (p-1)(q-1)		(secret)
Public key e	2^16+1	
Private key d		

Store key Cancel

Step 6. Click on Generate Prime Numbers and then click on the Apply Primes button. After this, click on Store Key to save the generated key pair.


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
Step by Step Signature Generation
Open document
Select hash function
Generate key
Provide certificate

Prime Number Generation

Prime numbers play an important role in modern cryptography. Here you can generate primes within a given value range [lower limit, upper limit].

Amount of prime numbers to be generated
(●) Generate two primes randomly from within the value range(s)
( ) Generate all primes within the value range set for p
Separator for the display of the primes:

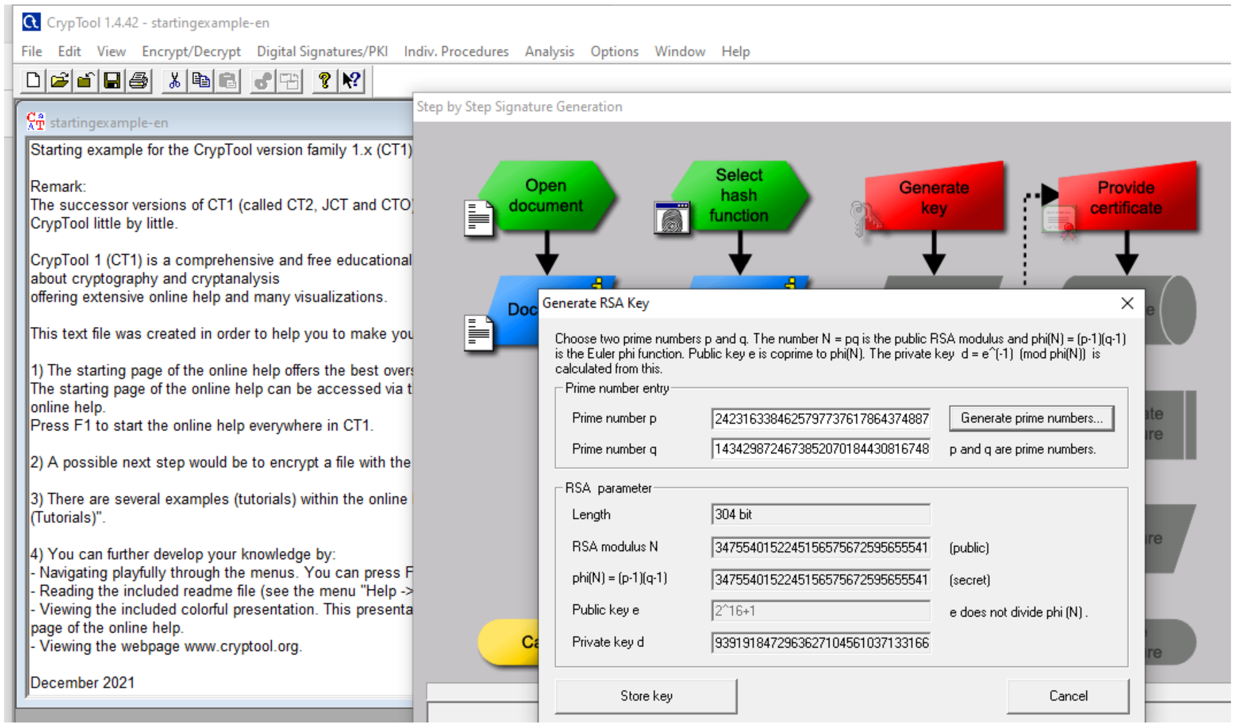
Algorithms for prime number generation
(●) Miller-Rabin Test
( ) Solovay-Strassen Test
( ) Fermat Test

Value range of the prime numbers p and q
( ) To be entered independently of each other
(●) Both are equal (just enter one)

Prime number p		Prime number q	
Lower limit	2^150	Lower limit	2^150
Upper limit	2^151	Upper limit	2^151
Result	0	Result	0

Generate prime numbers Apply primes Cancel

Step 7. In the flow chart, click on Provide Certificate.
The Create Certificate and PSE (Personal Security Environment) window will appear.


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
Step by Step Signature Generation
Open document
Select hash function
Generate key
Provide certificate
Doc
Ca

Starting example for the CrypTool version family 1.x (CT1)

Remark:
The successor versions of CT1 (called CT2, JCT and CTO
CrypTool little by little.

CrypTool 1 (CT1) is a comprehensive and free educational
about cryptography and cryptanalysis
offering extensive online help and many visualizations.

This text file was created in order to help you to make you

1) The starting page of the online help offers the best overs
The starting page of the online help can be accessed via t
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Generate RSA Key

Choose two prime numbers p and q. The number N = pq is the public RSA modulus and phi(N) = (p-1)(q-1) is the Euler phi function. Public key e is coprime to phi(N). The private key d = e^(-1) (mod phi(N)) is calculated from this.

Prime number entry

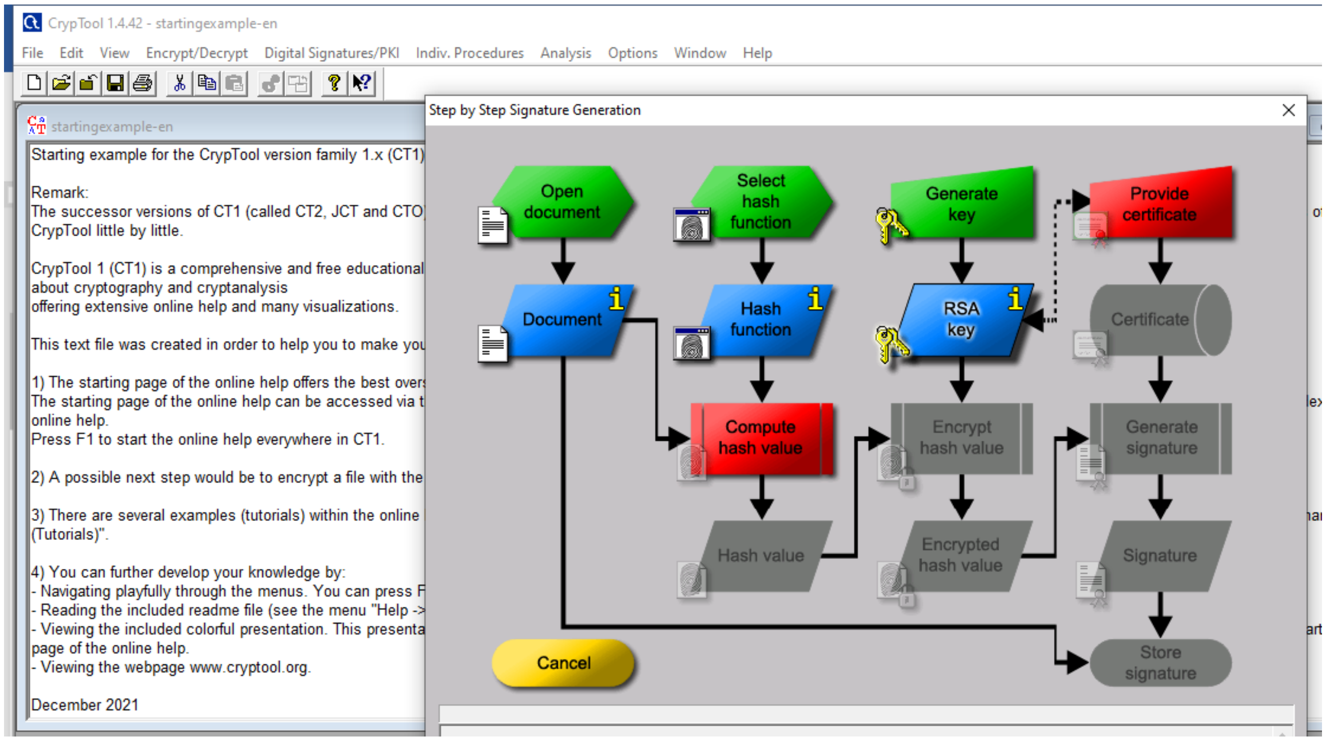
Prime number p	2423163384625797737617864374887	Generate prime numbers...
Prime number q	1434298724673852070184430816748	p and q are prime numbers.

RSA parameter

Length	304 bit	
RSA modulus N	3475540152245156575672595655541	(public)
phi(N) = (p-1)(q-1)	3475540152245156575672595655541	(secret)
Public key e	2^16+1	e does not divide phi (N) .
Private key d	9391918472963627104561037133166	

Store key Cancel

Step 8. Enter the required personal data (name, organization, email, etc.) for the certificate. Click on the Create Certificate and PSE button to generate your certificate.



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- Viewing the webpage www.cryptool.org.

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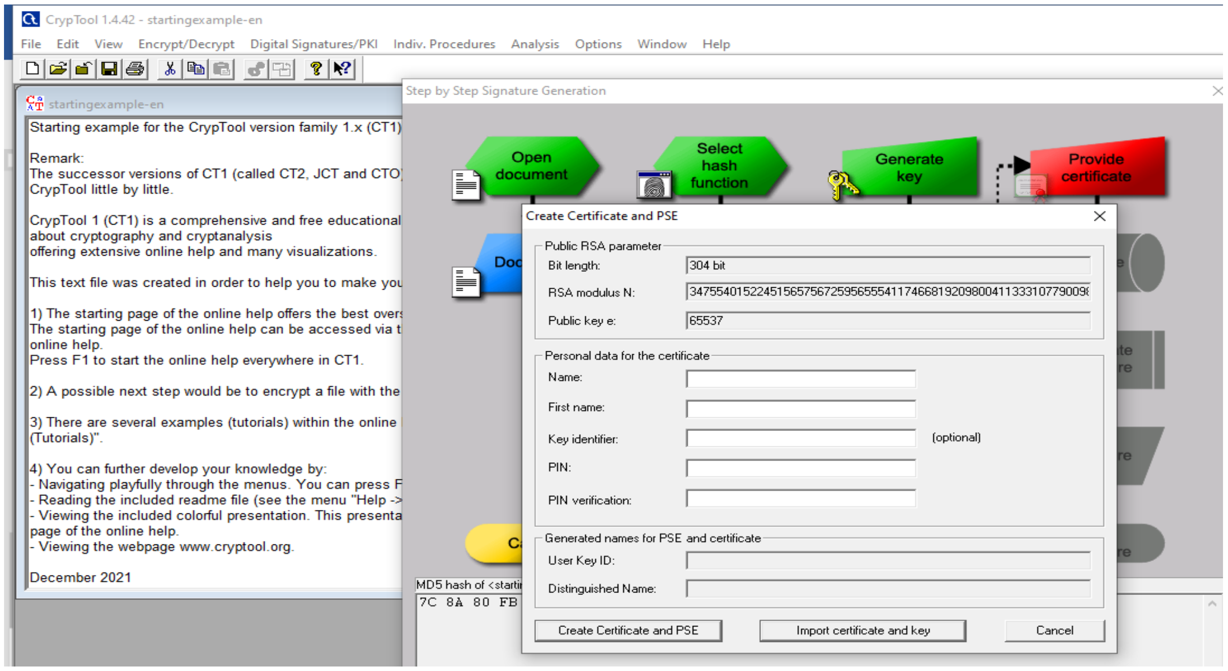
Step 9. On the flow chart, click on Hash Value.
This will compute the hash of your selected data using the chosen hash function.


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
Step by Step Signature Generation
Open document
Select hash function
Generate key
Provide certificate
Doc
C

Starting example for the CrypTool version family 1.x (CT1)

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page of the online help.
- Viewing the webpage www.cryptool.org.

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MD5 hash of <starti
7C 8A 80 FB

Create Certificate and PSE

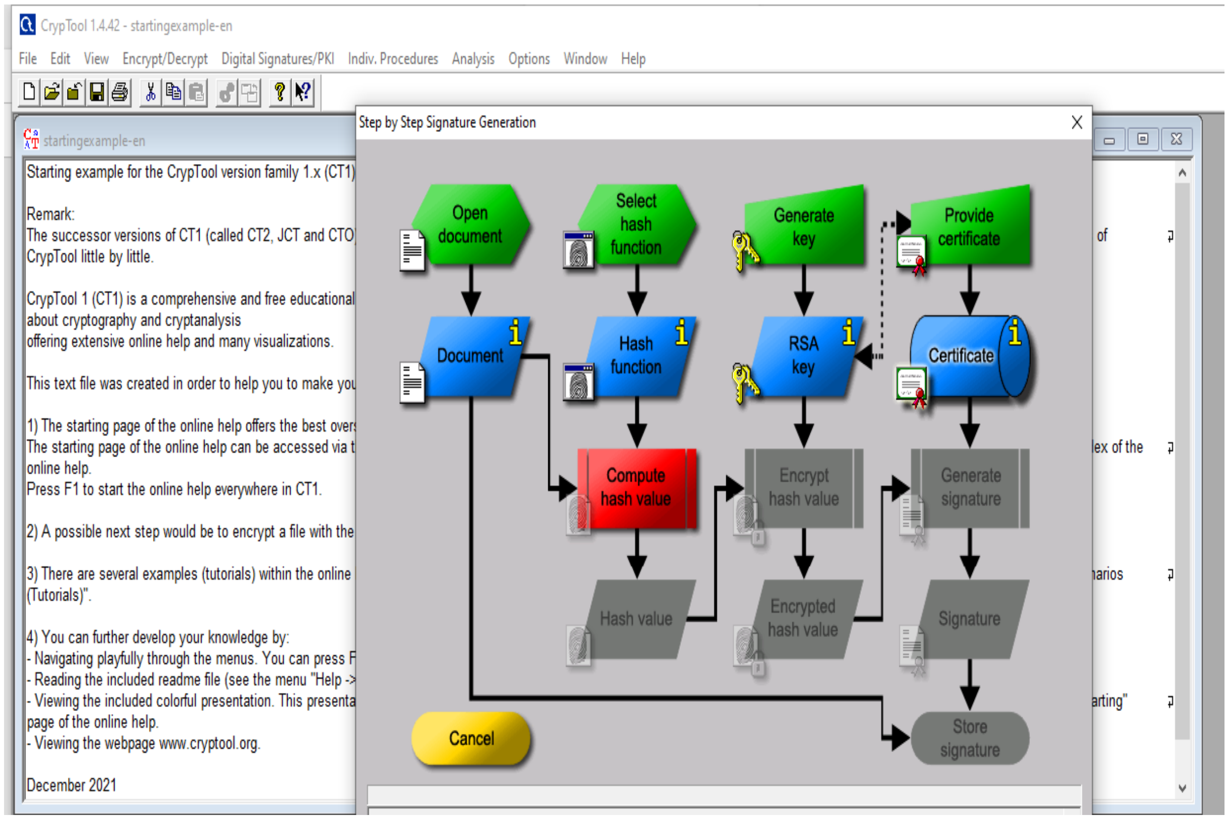
Public RSA parameter
Bit length: 304 bit
RSA modulus N: 34755401522451565756725956555411746681920980041133310779009
Public key e: 65537

Personal data for the certificate
Name:
First name:
Key identifier: (optional)
PIN:
PIN verification:

Generated names for PSE and certificate
User Key ID:
Distinguished Name:

Create Certificate and PSE | Import certificate and key | Cancel

Step 10. Next, click on Encrypt Hash Value.
This step encrypts the computed hash using your private key to generate the digital signature.



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page of the online help.
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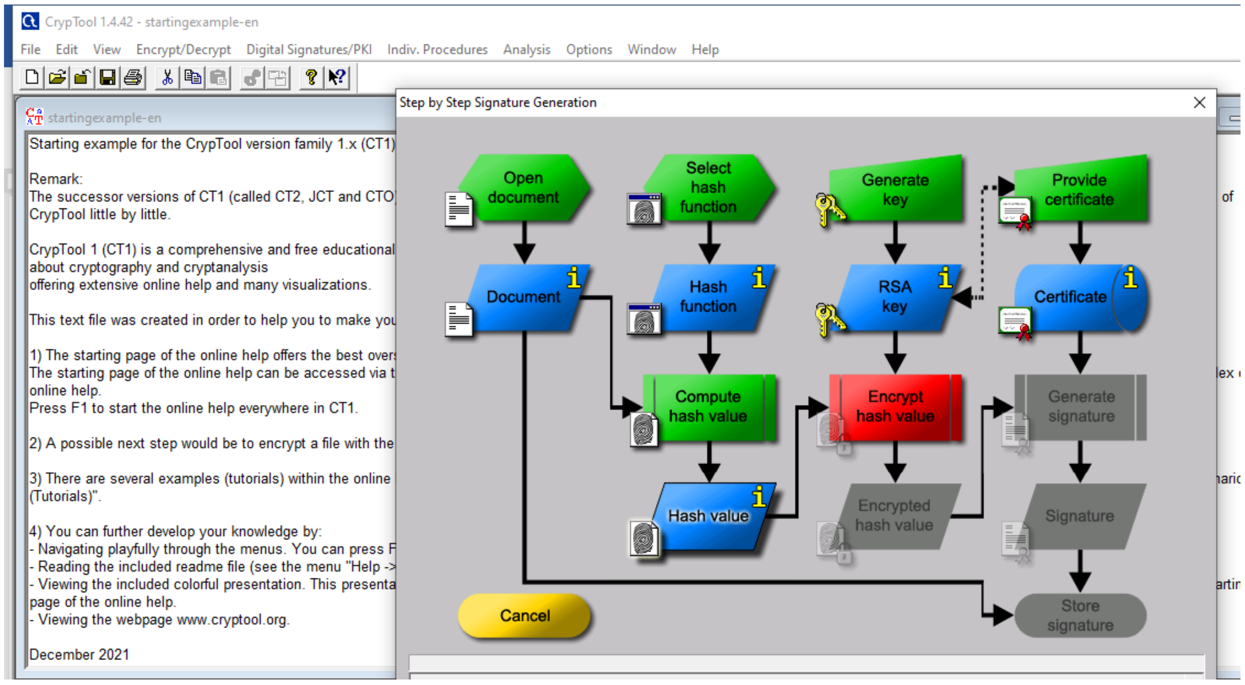
Step 11. Click on Generate Signature.
The tool will create the Digital Signature using the encryption algorithm.



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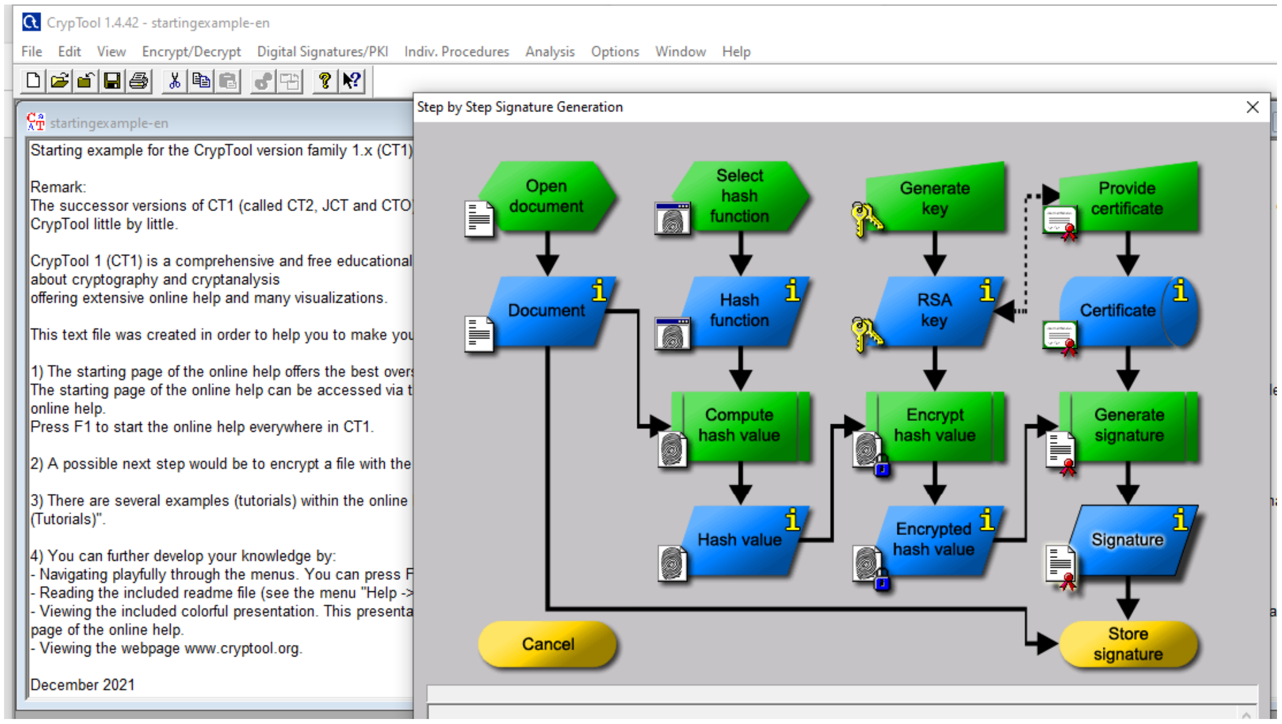
Step 12. After the signature is generated, click on Store Signature to save it.



Starting example for the CrypTool version family 1.x (CT1)

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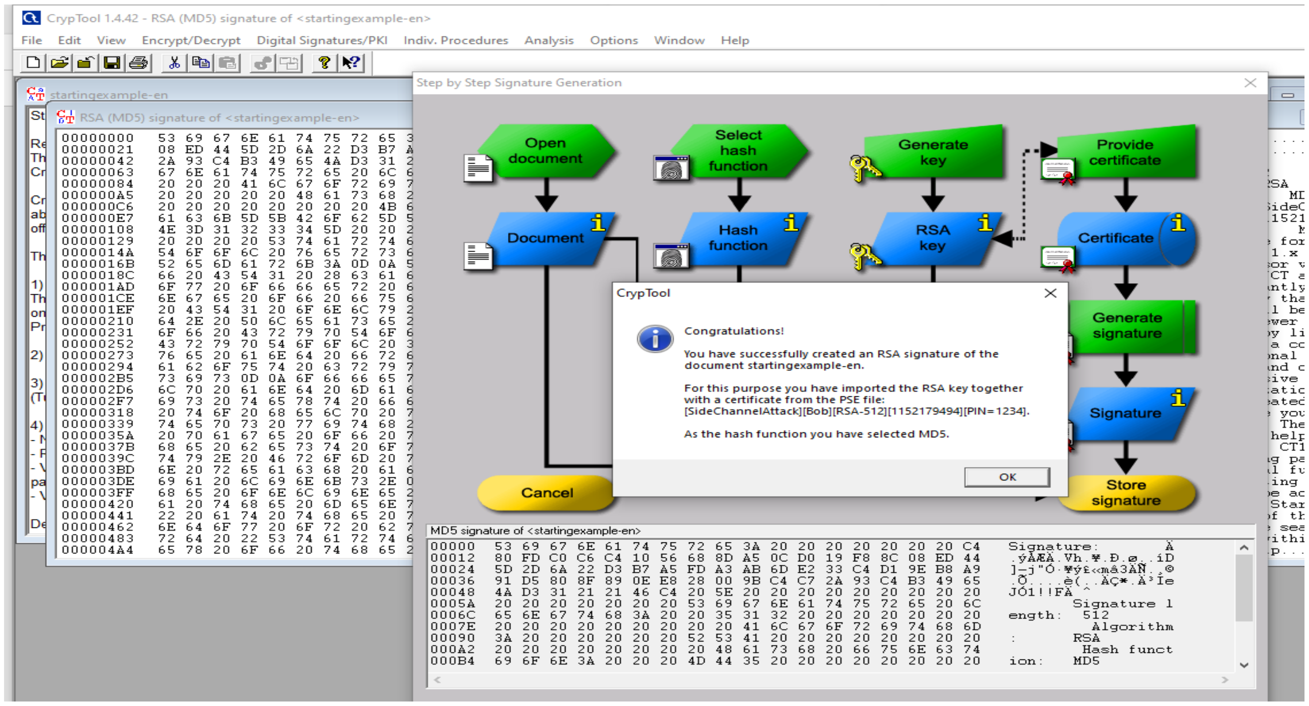
Step 13. A message box will appear stating:
"Congratulations! You have successfully created an RSA Signature."
Click OK to confirm.


CrypTool 1.4.42 - RSA (MD5) signature of <startingexample-en>
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
RSA (MD5) signature of <startingexample-en>
Step by Step Signature Generation
Open document
Select hash function
Generate key
Provide certificate
Document
Hash function
RSA key
Certificate
Generate signature
Signature
Cancel
Store signature
OK

CrypTool

Congratulations!

You have successfully created an RSA signature of the document startingexample-en.

For this purpose you have imported the RSA key together with a certificate from the PSE file:
[SideChannelAttack][Bob][RSA-512][1152179494][PIN=1234].

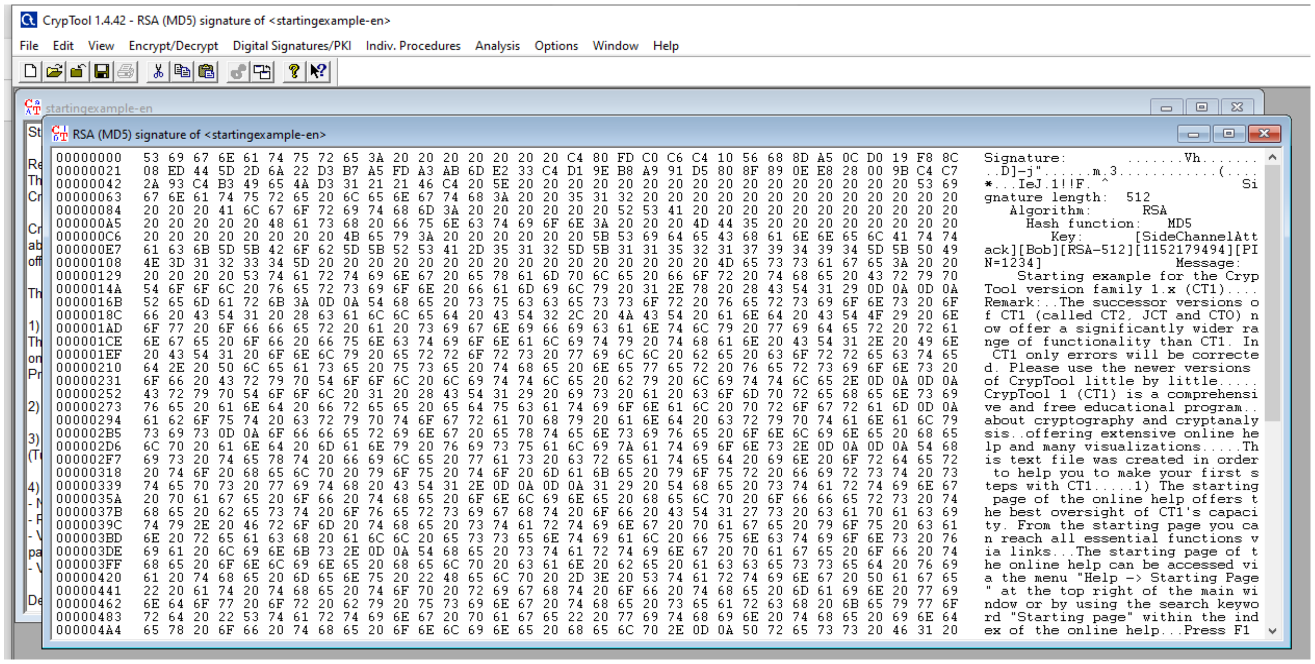
As the hash function you have selected MD5.

MD5 signature of <startingexample-en>

```
00000   53 69 67 6E 61 74 75 72 65 3A 20 20 20 20 20 20 20 C4   Signature:       Ä
00012   80 FD C0 C6 C4 10 56 68 8D A5 0C D0 19 F8 8C 08 ED 44   .ýÀÆÄ.Vh.¥.Ð.ø..íD
00024   5D 2D 6A 22 D3 B7 A5 FD A3 AB 6D E2 33 C4 D1 9E B8 A9   ]-j"Ó·¥ý£«mâ3ÄÑ.¸©
00036   91 D5 80 8F 89 0E E8 28 00 9B C4 C7 2A 93 C4 B3 49 65   .Õ....è(..ÄÇ*.Ä³Ie
00048   4A D3 31 21 21 46 C4 20 5E 20 20 20 20 20 20 20 20 20   JÓ1!!FÄ ^
0005A   20 20 20 20 20 20 20 53 69 67 6E 61 74 75 72 65 20 6C          Signature l
0006C   65 6E 67 74 68 3A 20 20 35 31 32 20 20 20 20 20 20 20   ength:  512
0007E   20 20 20 20 20 20 20 20 20 41 6C 67 6F 72 69 74 68 6D            Algorithm
00090   3A 20 20 20 20 20 20 52 53 41 20 20 20 20 20 20 20 20   :      RSA
000A2   20 20 20 20 20 20 20 20 48 61 73 68 20 66 75 6E 63 74           Hash funct
000B4   69 6F 6E 3A 20 20 20 4D 44 35 20 20 20 20 20 20 20 20   ion:   MD5
```

Step 14. Finally, the system will display a window showing the document created with a unique digital signature.

This indicates successful completion of the digital signature creation process.


CrypTool 1.4.42 - RSA (MD5) signature of <startingexample-en>
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
RSA (MD5) signature of <startingexample-en>

```
00000000   53 69 67 6E 61 74 75 72 65 3A 20 20 20 20 20 20 20 C4 80 FD C0 C6 C4 10 56 68 8D A5 0C D0 19 F8 8C   Signature:       .......Vh.......
00000021   08 ED 44 5D 2D 6A 22 D3 B7 A5 FD A3 AB 6D E2 33 C4 D1 9E B8 A9 91 D5 80 8F 89 0E E8 28 00 9B C4 C7   ..D]-j"......m.3............(....
00000042   2A 93 C4 B3 49 65 4A D3 31 21 21 46 C4 20 5E 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 53 69   *...IeJ.1!!F. ^                Si
00000063   67 6E 61 74 75 72 65 20 6C 65 6E 67 74 68 3A 20 20 35 31 32 20 20 20 20 20 20 20 20 20 20 20 20 20   gnature length:  512
00000084   20 20 20 41 6C 67 6F 72 69 74 68 6D 3A 20 20 20 20 20 20 52 53 41 20 20 20 20 20 20 20 20 20 20 20      Algorithm:      RSA
000000A5   20 20 20 20 20 48 61 73 68 20 66 75 6E 63 74 69 6F 6E 3A 20 20 20 4D 44 35 20 20 20 20 20 20 20 20        Hash function:   MD5
000000C6   20 20 20 20 20 20 20 20 4B 65 79 3A 20 20 20 20 20 20 5B 53 69 64 65 43 68 61 6E 6E 65 6C 41 74 74           Key:      [SideChannelAtt
000000E7   61 63 6B 5D 5B 42 6F 62 5D 5B 52 53 41 2D 35 31 32 5D 5B 31 31 35 32 31 37 39 34 39 34 5D 5B 50 49   ack][Bob][RSA-512][1152179494][PI
00000108   4E 3D 31 32 33 34 5D 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 4D 65 73 73 61 67 65 3A 20 20   N=1234]                Message:
00000129   20 20 20 20 53 74 61 72 74 69 6E 67 20 65 78 61 6D 70 6C 65 20 66 6F 72 20 74 68 65 20 43 72 79 70       Starting example for the Cryp
0000014A   54 6F 6F 6C 20 76 65 72 73 69 6F 6E 20 66 61 6D 69 6C 79 20 31 2E 78 20 28 43 54 31 29 0D 0A 0D 0A   Tool version family 1.x (CT1)....
0000016B   52 65 6D 61 72 6B 3A 0D 0A 54 68 65 20 73 75 63 63 65 73 73 6F 72 20 76 65 72 73 69 6F 6E 73 20 6F   Remark:..The successor versions o
0000018C   66 20 43 54 31 20 28 63 61 6C 6C 65 64 20 43 54 32 2C 20 4A 43 54 20 61 6E 64 20 43 54 4F 29 20 6E   f CT1 (called CT2, JCT and CTO) n
000001AD   6F 77 20 6F 66 66 65 72 20 61 20 73 69 67 6E 69 66 69 63 61 6E 74 6C 79 20 77 69 64 65 72 20 72 61   ow offer a significantly wider ra
000001CE   6E 67 65 20 6F 66 20 66 75 6E 63 74 69 6F 6E 61 6C 69 74 79 20 74 68 61 6E 20 43 54 31 2E 20 49 6E   nge of functionality than CT1. In
000001EF   20 43 54 31 20 6F 6E 6C 79 20 65 72 72 6F 72 73 20 77 69 6C 6C 20 62 65 20 63 6F 72 72 65 63 74 65    CT1 only errors will be correcte
00000210   64 2E 20 50 6C 65 61 73 65 20 75 73 65 20 74 68 65 20 6E 65 77 65 72 20 76 65 72 73 69 6F 6E 73 20   d. Please use the newer versions
00000231   6F 66 20 43 72 79 70 54 6F 6F 6C 20 6C 69 74 74 6C 65 20 62 79 20 6C 69 74 74 6C 65 2E 0D 0A 0D 0A   of CrypTool little by little.....
00000252   43 72 79 70 54 6F 6F 6C 20 31 20 28 43 54 31 29 20 69 73 20 61 20 63 6F 6D 70 72 65 68 65 6E 73 69   CrypTool 1 (CT1) is a comprehensi
00000273   76 65 20 61 6E 64 20 66 72 65 65 20 65 64 75 63 61 74 69 6F 6E 61 6C 20 70 72 6F 67 72 61 6D 0D 0A   ve and free educational program..
00000294   61 62 6F 75 74 20 63 72 79 70 74 6F 67 72 61 70 68 79 20 61 6E 64 20 63 72 79 70 74 61 6E 61 6C 79   about cryptography and cryptanaly
000002B5   73 69 73 0D 0A 6F 66 66 65 72 69 6E 67 20 65 78 74 65 6E 73 69 76 65 20 6F 6E 6C 69 6E 65 20 68 65   sis..offering extensive online he
000002D6   6C 70 20 61 6E 64 20 6D 61 6E 79 20 76 69 73 75 61 6C 69 7A 61 74 69 6F 6E 73 2E 0D 0A 0D 0A 54 68   lp and many visualizations.....Th
000002F7   69 73 20 74 65 78 74 20 66 69 6C 65 20 77 61 73 20 63 72 65 61 74 65 64 20 69 6E 20 6F 72 64 65 72   is text file was created in order
00000318   20 74 6F 20 68 65 6C 70 20 79 6F 75 20 74 6F 20 6D 61 6B 65 20 79 6F 75 72 20 66 69 72 73 74 20 73    to help you to make your first s
00000339   74 65 70 73 20 77 69 74 68 20 43 54 31 2E 0D 0A 0D 0A 31 29 20 54 68 65 20 73 74 61 72 74 69 6E 67   teps with CT1.....1) The starting
0000035A   20 70 61 67 65 20 6F 66 20 74 68 65 20 6F 6E 6C 69 6E 65 20 68 65 6C 70 20 6F 66 66 65 72 73 20 74    page of the online help offers t
0000037B   68 65 20 62 65 73 74 20 6F 76 65 72 73 69 67 68 74 20 6F 66 20 43 54 31 27 73 20 63 61 70 61 63 69   he best oversight of CT1's capaci
0000039C   74 79 2E 20 46 72 6F 6D 20 74 68 65 20 73 74 61 72 74 69 6E 67 20 70 61 67 65 20 79 6F 75 20 63 61   ty. From the starting page you ca
000003BD   6E 20 72 65 61 63 68 20 61 6C 6C 20 65 73 73 65 6E 74 69 61 6C 20 66 75 6E 63 74 69 6F 6E 73 20 76   n reach all essential functions v
000003DE   69 61 20 6C 69 6E 6B 73 2E 0D 0A 54 68 65 20 73 74 61 72 74 69 6E 67 20 70 61 67 65 20 6F 66 20 74   ia links...The starting page of t
000003FF   68 65 20 6F 6E 6C 69 6E 65 20 68 65 6C 70 20 63 61 6E 20 62 65 20 61 63 63 65 73 73 65 64 20 76 69   he online help can be accessed vi
00000420   61 20 74 68 65 20 6D 65 6E 75 20 22 48 65 6C 70 20 2D 3E 20 53 74 61 72 74 69 6E 67 20 50 61 67 65   a the menu "Help -> Starting Page
00000441   22 20 61 74 20 74 68 65 20 74 6F 70 20 72 69 67 68 74 20 6F 66 20 74 68 65 20 6D 61 69 6E 20 77 69   " at the top right of the main wi
00000462   6E 64 6F 77 20 6F 72 20 62 79 20 75 73 69 6E 67 20 74 68 65 20 73 65 61 72 63 68 20 6B 65 79 77 6F   ndow or by using the search keywo
00000483   72 64 20 22 53 74 61 72 74 69 6E 67 20 70 61 67 65 22 20 77 69 74 68 69 6E 20 74 68 65 20 69 6E 64   rd "Starting page" within the ind
000004A4   65 78 20 6F 66 20 74 68 65 20 6F 6E 6C 69 6E 65 20 68 65 6C 70 2E 0D 0A 50 72 65 73 73 20 46 31 20   ex of the online help...Press F1
```

IX. Precautions

1. Keep your private key confidential.
2. Use strong key lengths (minimum 2048 bits for RSA).
3. Verify both the message and the signature file for integrity.
4. Do not modify the signed message before verification.

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Describe three main objectives of a digital signature?
2. Difference between a digital signature and an electronic signature.
3. What happens if the signed message is altered after signing?
4. Generate and verify a digital signature using RSA and SHA-256 in CrypTool.
5. Write a C program to simulate the generation of a digital signature.

Space for Answer

XI. Exercise

1. Demonstrate digital signature creation and verification using both RSA and DSA in CrypTool.
2. Observe how message alteration leads to signature verification failure.
3. Research and summarize how digital certificates are used to distribute public keys.

XII. References / Suggestions for further reading

1. Stallings, W. Cryptography and Network Security: Principles and Practice.
2. Kahate, A. Cryptography and Network Security.
3. NPTEL Course: Introduction to Cryptography and Network Security.
4. CrypTool Official Website: https://www.cryptool.org
5. Virtual Labs, IIIT Hyderabad: https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html

XIII. Assessment schemes

Performance Indicators		Weightage
Process related (15 Marks)		**60 %**
1	Correct generation of digital signature using CrypTool	20 %
2	Verification of digital signature using the corresponding public key	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Accuracy of signature verification results	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			Dated Signature of Teacher
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 13: Create and verify Digital Certificate using any Open-source tool (Example – CrypTool).

I. Practical Significance

This practical introduces digital certificates, which are electronic credentials issued by a trusted authority (CA – Certificate Authority) to verify the identity of entities involved in digital communication. Students will learn the process of generating, signing, and verifying digital certificates using an open-source cryptographic tool such as CrypTool, gaining a clear understanding of how certificates ensure trust, authentication, and secure communication over the Internet.

II. Industry / Employer Expected Outcome

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO4 – Use tools and techniques to prevent cyber attacks.

IV. Laboratory Learning Outcome (LLO)

LLO 13.1: Generate digital Certificate.

V. Relevant Affective domain related Outcomes(s)

1. Responsibility: Apply tools properly for secure certificate creation and verification.
2. Ethical Awareness: Understand the significance of certificate-based authentication in secure communications.
3. Analytical Skills: Analyze the certificate details to interpret issuer, validity period, and public key information.

VI. Theoretical Background

A **digital certificate** is an electronic document that binds a **public key** with an entity’s identity (such as a person, organization, or website).
It is issued and digitally signed by a trusted **Certificate Authority (CA)** as part of the **Public Key Infrastructure (PKI)** system.
A valid digital certificate contains:

- **Subject name** (owner’s identity)
- **Public key**
- **Issuer name (CA)**
- **Validity period**
- **Digital signature of CA**

Digital certificates are used in:

- **SSL/TLS** protocols for secure web communication.
- **Email encryption and signing**.

- **Software signing** to prove authenticity of programs.

Types of Certificates:

- **Self-signed certificate** (created and verified locally)
- **CA-signed certificate** (issued by trusted third-party authority)

VII. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows XP / 7 onwards / LINUX V 5.0 or latest		
3	Tools / Software Required	CrypTool 1.4.42		

VIII. Procedure

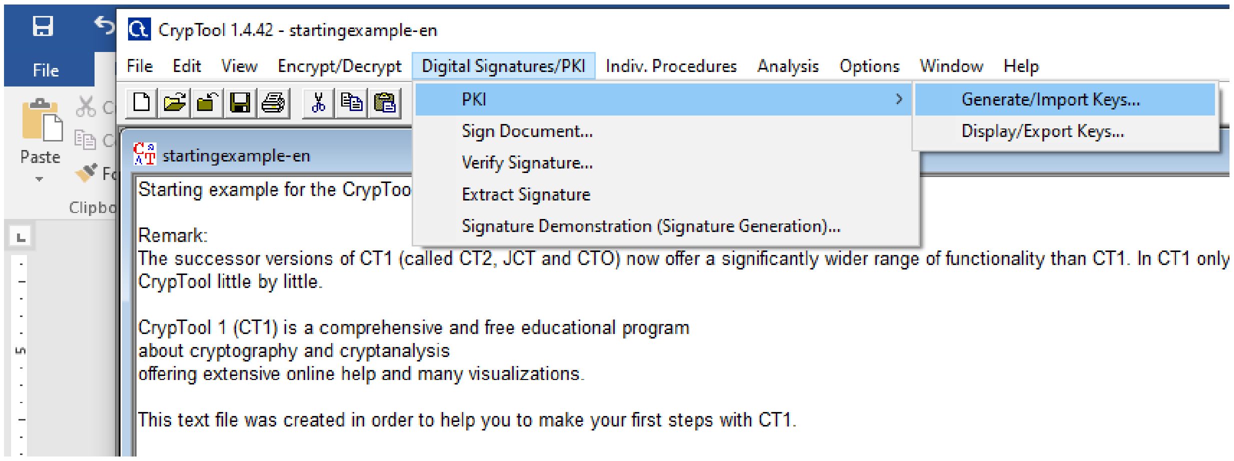
Step-by-Step Procedure

Step 1. Perform all the steps as outlined in Practical No. 12 to generate a Digital Signature.

A. Creating Keys and Certificate

1. Open CrypTool 1.4.42.
2. Go to:

Menu → Public Key → Generate/Import Keys → Generate new key pair


CrypTool 1.4.42 - startingexample-en
File
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
PKI
Generate/Import Keys...
Display/Export Keys...
Sign Document...
Verify Signature...
Extract Signature
Signature Demonstration (Signature Generation)...
Paste
Clipbo
startingexample-en

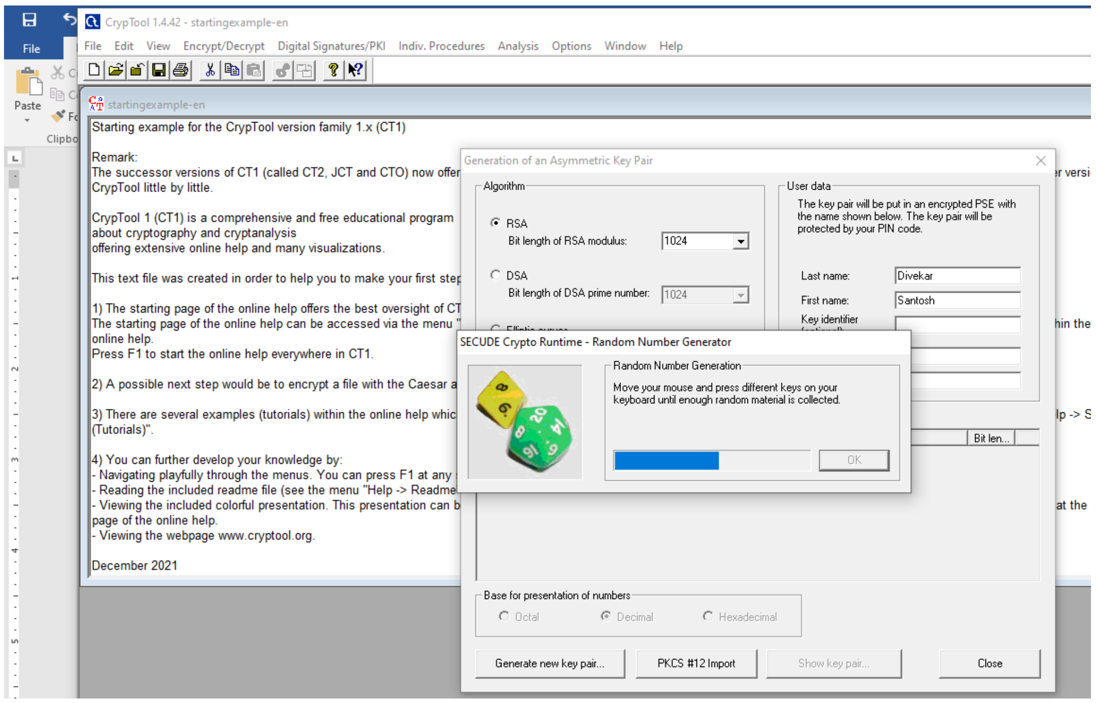
Starting example for the CrypToo

Remark:
The successor versions of CT1 (called CT2, JCT and CTO) now offer a significantly wider range of functionality than CT1. In CT1 only
CrypTool little by little.

CrypTool 1 (CT1) is a comprehensive and free educational program
about cryptography and cryptanalysis
offering extensive online help and many visualizations.

This text file was created in order to help you to make your first steps with CT1.

3. Choose algorithm (e.g., RSA).
4. Enter:
   - Owner's name
   - Email address
   - Key length (e.g., 1024 bits)


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en

Starting example for the CrypTool version family 1.x (CT1)

Remark:
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1) The starting page of the online help offers the best oversight of CT
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Press F1 to start the online help everywhere in CT1.

2) A possible next step would be to encrypt a file with the Caesar a

3) There are several examples (tutorials) within the online help whic
(Tutorials)".

4) You can further develop your knowledge by:
- Navigating playfully through the menus. You can press F1 at any
- Reading the included readme file (see the menu "Help -> Readme
- Viewing the included colorful presentation. This presentation can b
page of the online help.
- Viewing the webpage www.cryptool.org.

December 2021

Generation of an Asymmetric Key Pair

Algorithm: (● RSA) Bit length of RSA modulus: 1024 ; DSA Bit length of DSA prime number: 1024

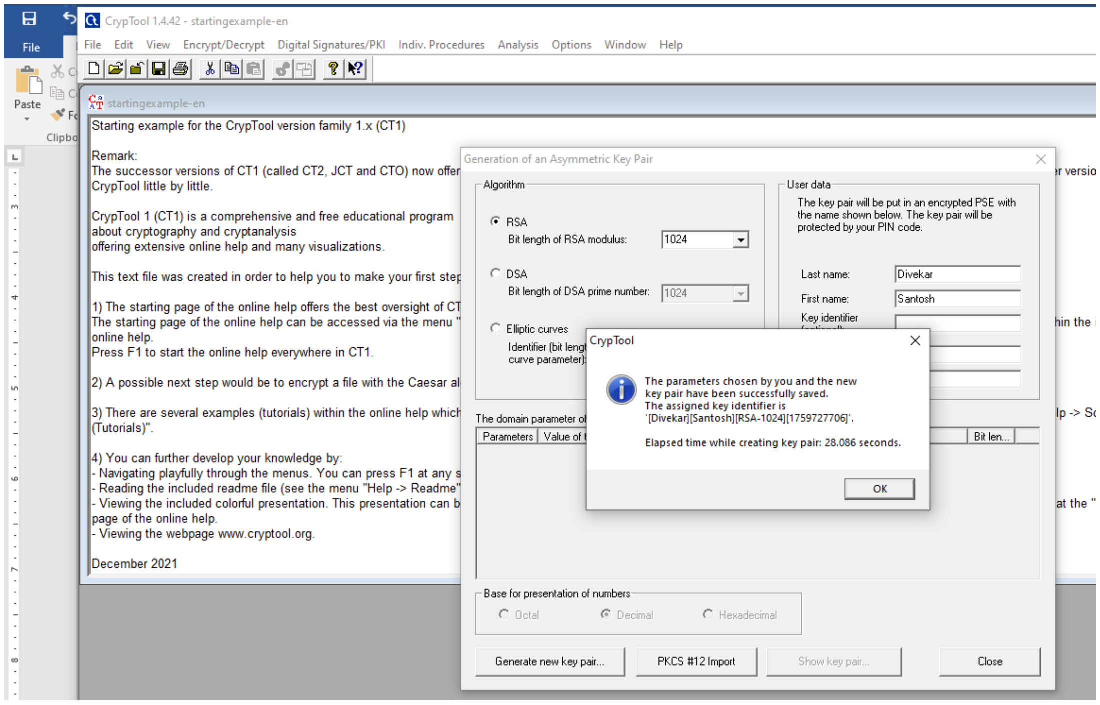
User data: The key pair will be put in an encrypted PSE with the name shown below. The key pair will be protected by your PIN code.

Last name: Divekar
First name: Santosh
Key identifier

SECUDE Crypto Runtime - Random Number Generator

Random Number Generation: Move your mouse and press different keys on your keyboard until enough random material is collected.

5. Click Generate key pair.


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
Generation of an Asymmetric Key Pair

Algorithm: (● RSA) Bit length of RSA modulus: 1024 ; DSA Bit length of DSA prime number: 1024 ; Elliptic curves

Last name: Divekar
First name: Santosh

CrypTool

The parameters chosen by you and the new key pair have been successfully saved.
The assigned key identifier is
'[Divekar][Santosh][RSA-1024][1759727706]'.

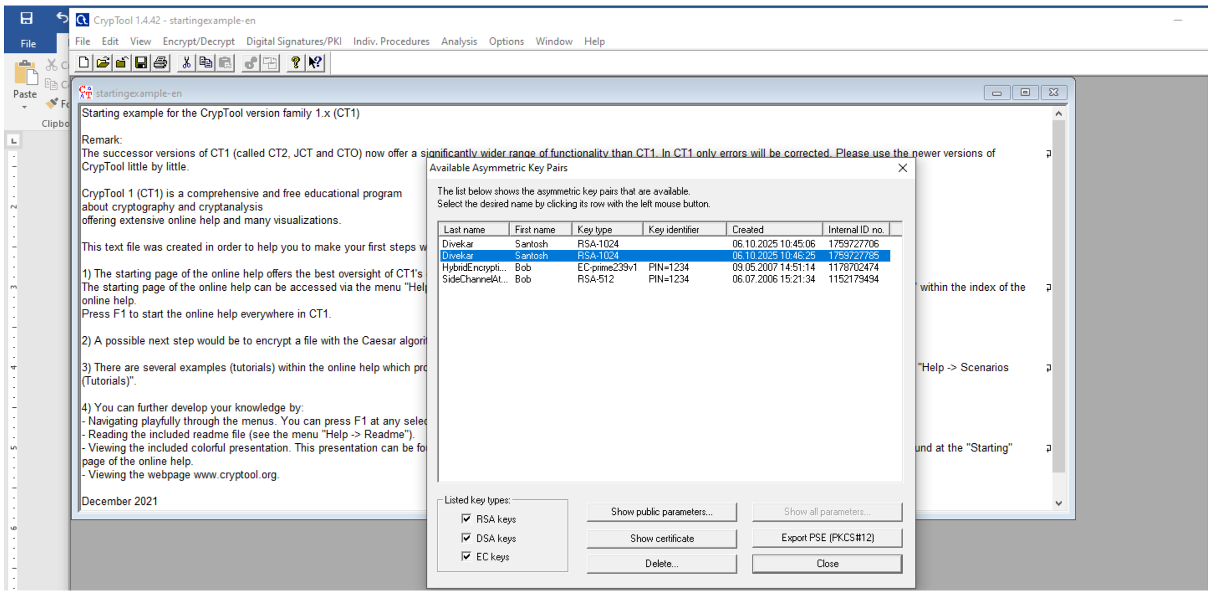
Elapsed time while creating key pair: 28.086 seconds.

OK
Base for presentation of numbers
Octal
Decimal
Hexadecimal
Generate new key pair...
PKCS #12 Import
Show key pair...
Close

6. Now go to:

Menu → Public Key → Certificates → Create X.509 Certificate

7. Fill in the certificate details:
   - Owner name
   - Organization
   - Validity period



CrypTool 1.4.42 - startingexample-en

Starting example for the CrypTool version family 1.x (CT1)

Remark:
The successor versions of CT1 (called CT2, JCT and CTO) now offer a significantly wider range of functionality than CT1. In CT1 only errors will be corrected. Please use the newer versions of CrypTool little by little.

CrypTool 1 (CT1) is a comprehensive and free educational program about cryptography and cryptanalysis offering extensive online help and many visualizations.

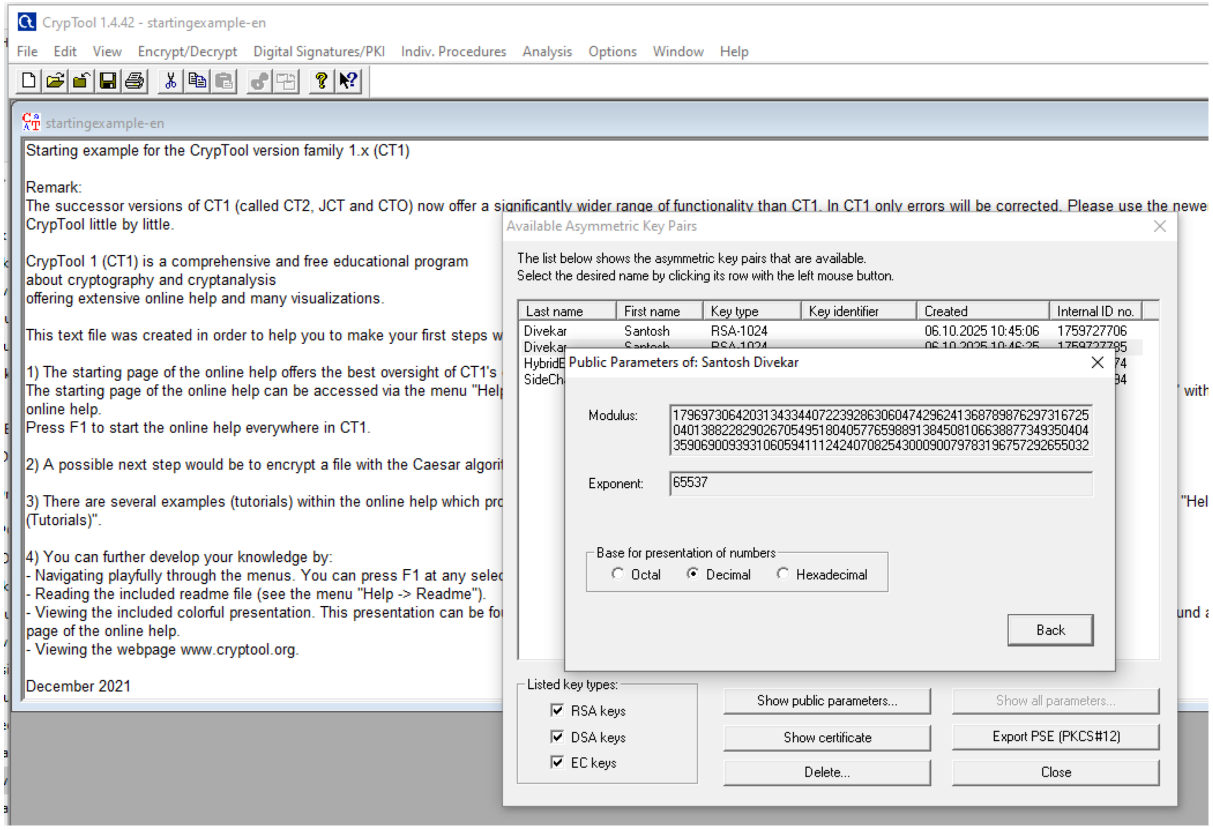
Available Asymmetric Key Pairs

The list below shows the asymmetric key pairs that are available.
Select the desired name by clicking its row with the left mouse button.

Last name	First name	Key type	Key identifier	Created	Internal ID no.
Divekar	Santosh	RSA-1024		06.10.2025 10:45:06	1759727706
Divekar	Santosh	RSA-1024		06.10.2025 10:46:25	1759727785
HybridEncrypti...	Bob	EC-prime239v1	PIN=1234	09.05.2007 14:51:14	1178702474
SideChannelAt...	Bob	RSA-512	PIN=1234	06.07.2006 15:21:34	1152179494

Listed key types: ☑ RSA keys ☑ DSA keys ☑ EC keys

8. Select the private key you just generated.



Public Parameters of: Santosh Divekar

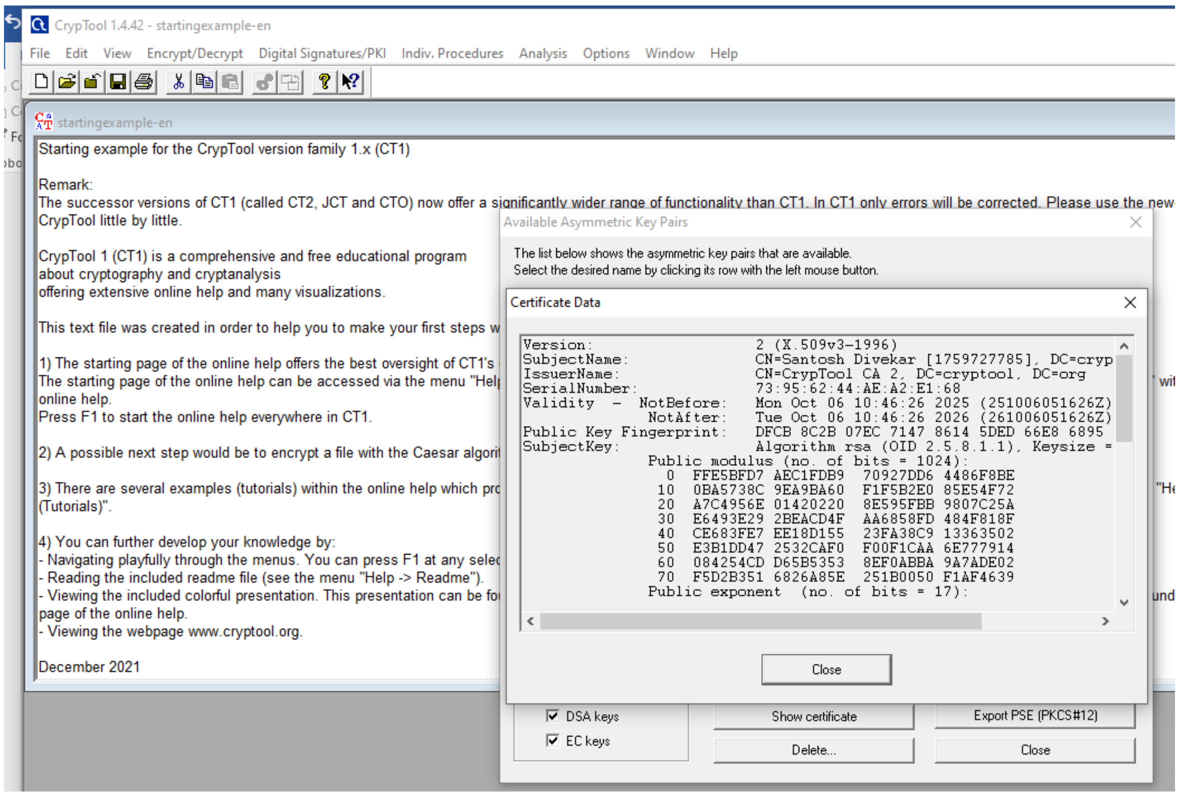
Modulus: 179697306420313433440722392863060474296241368789876297316725040138822829026705495180405776598891384508106638877349350404359069009393106059411124240708254300090079783196757292655032

Exponent: 65537

Base for presentation of numbers: Octal [✓ Decimal] Hexadecimal

9. Click Sign Certificate.

CrypTool will use your private key (or a CA's private key) to sign the certificate.


CrypTool 1.4.42 - startingexample-en
File Edit View Encrypt/Decrypt Digital Signatures/PKI Indiv. Procedures Analysis Options Window Help
startingexample-en
Available Asymmetric Key Pairs
DSA keys
EC keys
Show certificate
Export PSE (PKCS#12)
Delete...
Close

Starting example for the CrypTool version family 1.x (CT1)

Remark:
The successor versions of CT1 (called CT2, JCT and CTO) now offer a significantly wider range of functionality than CT1. In CT1 only errors will be corrected. Please use the new
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- Viewing the included colorful presentation. This presentation can be fo
page of the online help.
- Viewing the webpage www.cryptool.org.

December 2021

The list below shows the asymmetric key pairs that are available.
Select the desired name by clicking its row with the left mouse button.

Certificate Data

```
Version:                    2 (X.509v3-1996)
SubjectName:                CN=Santosh Divekar [1759727785], DC=cryp
IssuerName:                 CN=CrypTool CA 2, DC=cryptool, DC=org
SerialNumber:               73:95:62:44:AE:A2:E1:68
Validity  -  NotBefore:     Mon Oct 06 10:46:26 2025 (251006051626Z)
              NotAfter:     Tue Oct 06 10:46:26 2026 (261006051626Z)
Public Key Fingerprint:     DFCB 8C2B 07EC 7147 8614 5DED 66E8 6895
SubjectKey:                 Algorithm rsa (OID 2.5.8.1.1), Keysize =
              Public modulus (no. of bits = 1024):
                 0   FFE5BFD7 AEC1FDB9  70927DD6 4486F8BE
                10   0BA5738C 9EA9BA60  F1F5B2E0 85E54F72
                20   A7C4956E 01420220  8E595FBB 9807C25A
                30   E6493E29 2BEACD4F  AA6858FD 484F818F
                40   CE683FE7 EE18D155  23FA38C9 13363502
                50   E3B1DD47 2532CAF0  F00F1CAA 6E777914
                60   084254CD D65B5353  8EF0ABBA 9A7ADE02
                70   F5D2B351 6826A85E  251B0050 F1AF4639
              Public exponent  (no. of bits = 17):
```

10. Save the generated certificate (e.g., user_cert.cer).

IX. Precautions

1. Ensure the private key is securely stored and not shared.
2. Use valid certificate parameters (e.g., key size ≥ 2048 bits).
3. Check the validity period and issuer name before using certificates.
4. Do not modify certificate contents manually.

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Describe digital certificate. How does it differ from a digital signature?
2. Explain the role of a Certificate Authority (CA) in PKI.
3. How does a certificate ensure authenticity and trust in communication?
4. Create a self-signed certificate using CrypTool and verify its validity.
5. Identify key fields in a digital certificate (Issuer, Subject, Validity, Public Key, Signature).

Space for Answer

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XI. Exercise

1. Create and verify both a self-signed and CA-signed certificate using CrypTool.
2. Analyze certificate details and validity information.
3. Research how SSL/TLS uses certificates for website authentication.

XII. References / Suggestions for further reading

1. Stallings, W. Cryptography and Network Security: Principles and Practice.
2. Kahate, A. Cryptography and Network Security.
3. NPTEL Course: Introduction to Cryptography and Network Security.
4. CrypTool Official Website: https://www.cryptool.org
5. Virtual Labs, IIIT Hyderabad: https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html .

XIII. Assessment schemes

Performance Indicators		**Weightage**
Process related (15 Marks)		**60 %**
1	Correct creation of digital certificate using CrypTool	20 %
2	Verification and validation of certificate authenticity	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Accuracy of certificate details (validity, issuer, subject)	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 14: Configure Firewall Settings on any Operating System.

I. Practical Significance

This practical introduces the concept and configuration of a firewall, an essential security mechanism used to control incoming and outgoing network traffic. Students will learn how to configure firewall rules, ports, and permissions on an operating system to protect against unauthorized access and cyberattacks. The goal is to understand how firewalls safeguard systems by applying predefined security policies.

II. Industry / Employer Expected Outcome

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO4 – Use tools and techniques to prevent cyber attacks.

IV. Laboratory Learning Outcome (LLO)

LLO 14.1: Configure firewall.

V. Relevant Affective domain related Outcomes(s)

1. Responsibility: Properly manage system security configurations.
2. Ethical Awareness: Recognize the importance of safe and authorized network configurations.
3. Analytical Skills: Analyze the effect of firewall rules on network connectivity.

VI. Theoretical Background

A **firewall** is a network security system that monitors and controls incoming and outgoing network traffic based on predetermined security rules.
It acts as a barrier between a **trusted internal network** and an **untrusted external network (such as the Internet)**.

Types of Firewalls:

- **Packet Filtering Firewall:** Filters packets based on source/destination IP address, ports, and protocol.
- **Stateful Firewall:** Tracks the state of active connections and allows only legitimate packets.
- **Application Layer Firewall:** Filters traffic based on specific applications (e.g., HTTP, FTP).
- **Next-Generation Firewall (NGFW):** Integrates deep packet inspection, intrusion prevention, and application control.

Basic Firewall Operations:

1. Allow or block specific network traffic.
2. Control access to ports and protocols.
3. Prevent unauthorized inbound or outbound connections.
4. Log and monitor suspicious network activities.

Firewalls can be configured using **graphical interfaces** (Windows Firewall) or **command-line tools** (e.g., ufw in Linux).

VII. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows 10 / 11 / Linux (Ubuntu/CentOS)		
3	Tools / Software Required	Built-in Firewall Tools (Windows Defender Firewall / UFW)		

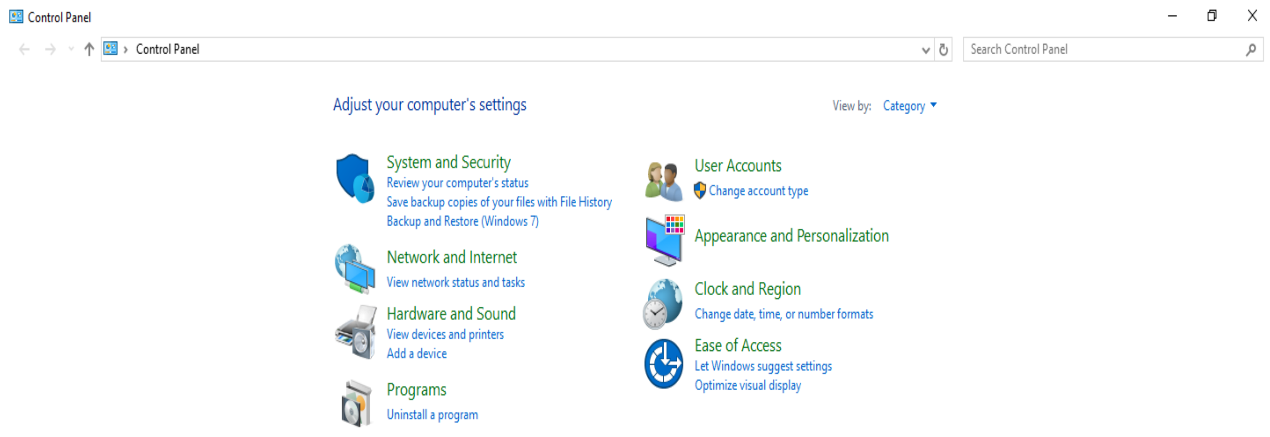
VIII. Procedure

Step-by-Step Procedure

A. Install Firewall on Windows Operating System

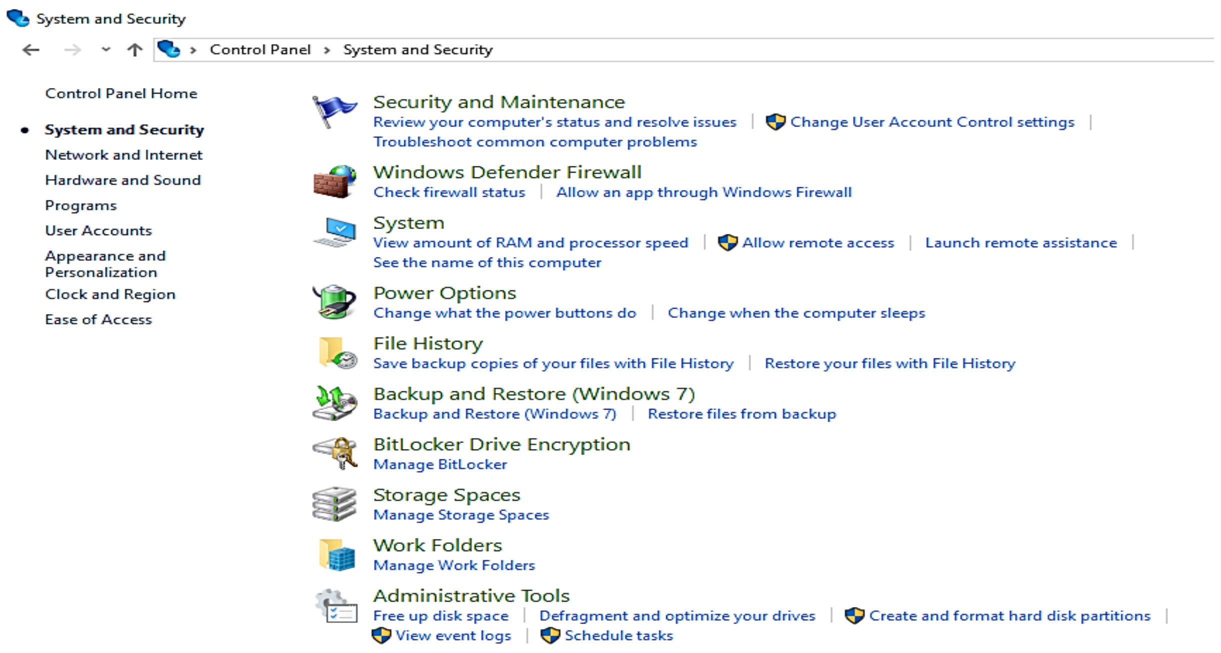
Step 1:

Open the Start Menu and click on Control Panel.


Control Panel
Control Panel
Search Control Panel
Adjust your computer's settings
View by: Category
System and Security
Review your computer's status
Save backup copies of your files with File History
Backup and Restore (Windows 7)
Network and Internet
View network status and tasks
Hardware and Sound
View devices and printers
Add a device
Programs
Uninstall a program
User Accounts
Change account type
Appearance and Personalization
Clock and Region
Change date, time, or number formats
Ease of Access
Let Windows suggest settings
Optimize visual display

Step 2:

In the Control Panel window, select System and Security.


System and Security

Control Panel > System and Security

Control Panel Home
- **System and Security**
- Network and Internet
- Hardware and Sound
- Programs
- User Accounts
- Appearance and Personalization
- Clock and Region
- Ease of Access

Security and Maintenance
Review your computer's status and resolve issues | Change User Account Control settings | Troubleshoot common computer problems

Windows Defender Firewall
Check firewall status | Allow an app through Windows Firewall

System
View amount of RAM and processor speed | Allow remote access | Launch remote assistance | See the name of this computer

Power Options
Change what the power buttons do | Change when the computer sleeps

File History
Save backup copies of your files with File History | Restore your files with File History

Backup and Restore (Windows 7)
Backup and Restore (Windows 7) | Restore files from backup

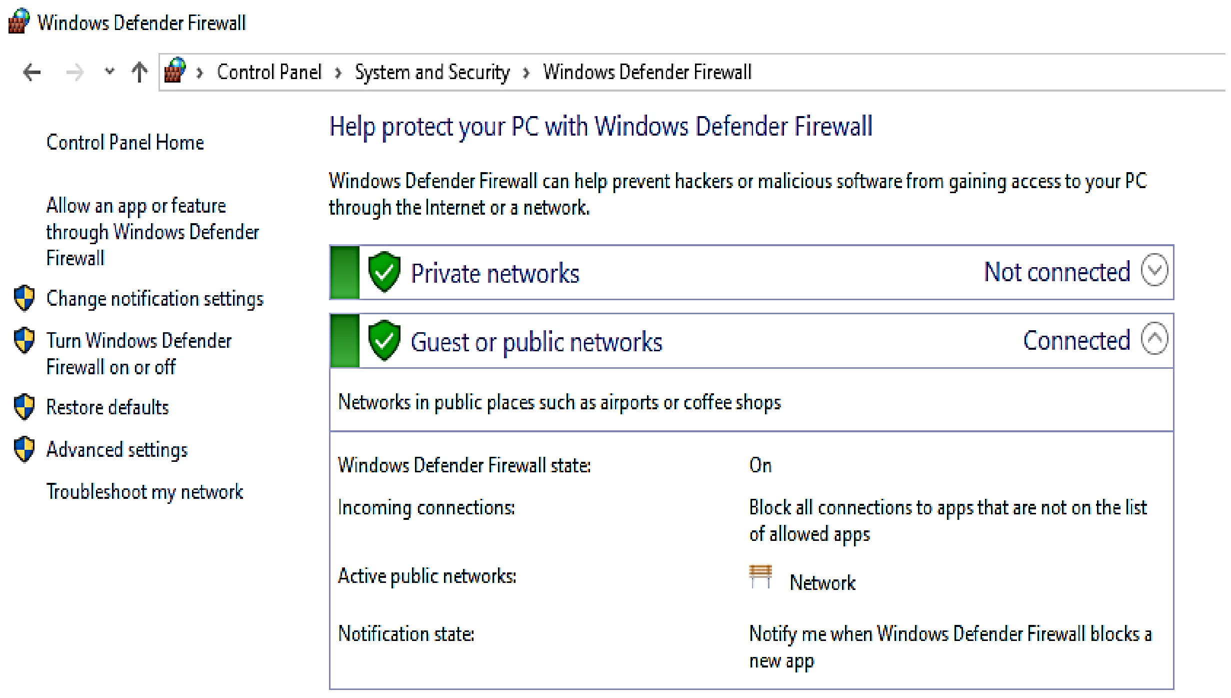
BitLocker Drive Encryption
Manage BitLocker

Storage Spaces
Manage Storage Spaces

Work Folders
Manage Work Folders

Administrative Tools
Free up disk space | Defragment and optimize your drives | Create and format hard disk partitions | View event logs | Schedule tasks

Step 3:
Click on "Windows Defender Firewall" option.
Then, click on "Turn Windows Defender Firewall on or off" from the left panel.


Windows Defender Firewall

Control Panel > System and Security > Windows Defender Firewall

Control Panel Home

Allow an app or feature through Windows Defender Firewall

Change notification settings

Turn Windows Defender Firewall on or off

Restore defaults

Advanced settings

Troubleshoot my network

Help protect your PC with Windows Defender Firewall

Windows Defender Firewall can help prevent hackers or malicious software from gaining access to your PC through the Internet or a network.

Private networks — Not connected

Guest or public networks — Connected

Networks in public places such as airports or coffee shops

Windows Defender Firewall state:	On
Incoming connections:	Block all connections to apps that are not on the list of allowed apps
Active public networks:	Network
Notification state:	Notify me when Windows Defender Firewall blocks a new app

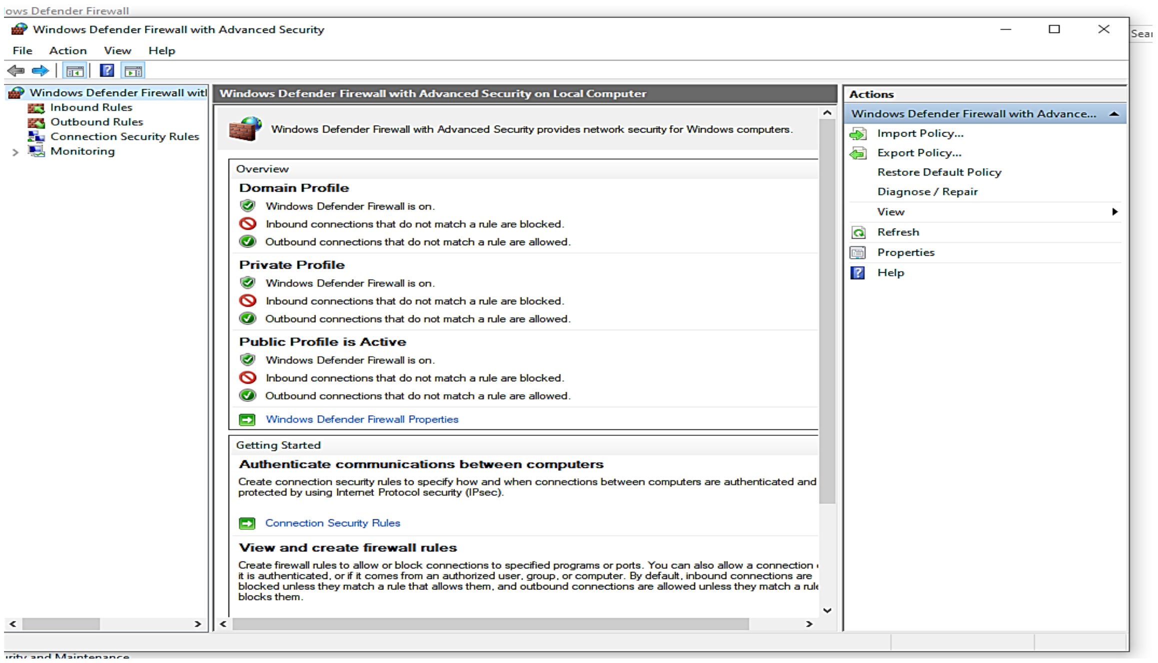
Step 4:

Choose Turn on Windows Defender Firewall under both Private and Public network settings. Click on OK to apply changes.

Step 5:

Modify settings as per requirement (for example, allow or block incoming connections, enable notifications, etc.).

Finally, click OK to save the configuration.



Windows Defender Firewall with Advanced Security on Local Computer

Windows Defender Firewall with Advanced Security provides network security for Windows computers.

Overview

Domain Profile
- Windows Defender Firewall is on.
- Inbound connections that do not match a rule are blocked.
- Outbound connections that do not match a rule are allowed.

Private Profile
- Windows Defender Firewall is on.
- Inbound connections that do not match a rule are blocked.
- Outbound connections that do not match a rule are allowed.

Public Profile is Active
- Windows Defender Firewall is on.
- Inbound connections that do not match a rule are blocked.
- Outbound connections that do not match a rule are allowed.

Windows Defender Firewall Properties

Getting Started

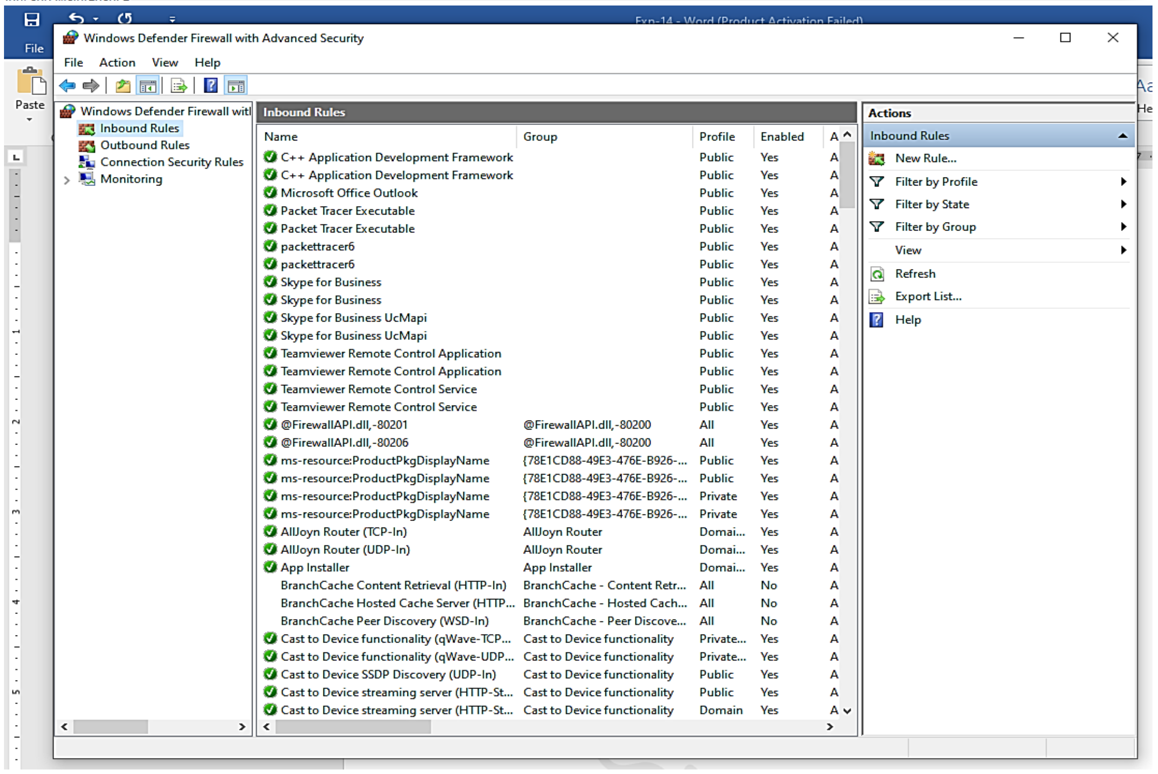
Authenticate communications between computers

Create connection security rules to specify how and when connections between computers are authenticated and protected by using Internet Protocol security (IPsec).

Connection Security Rules

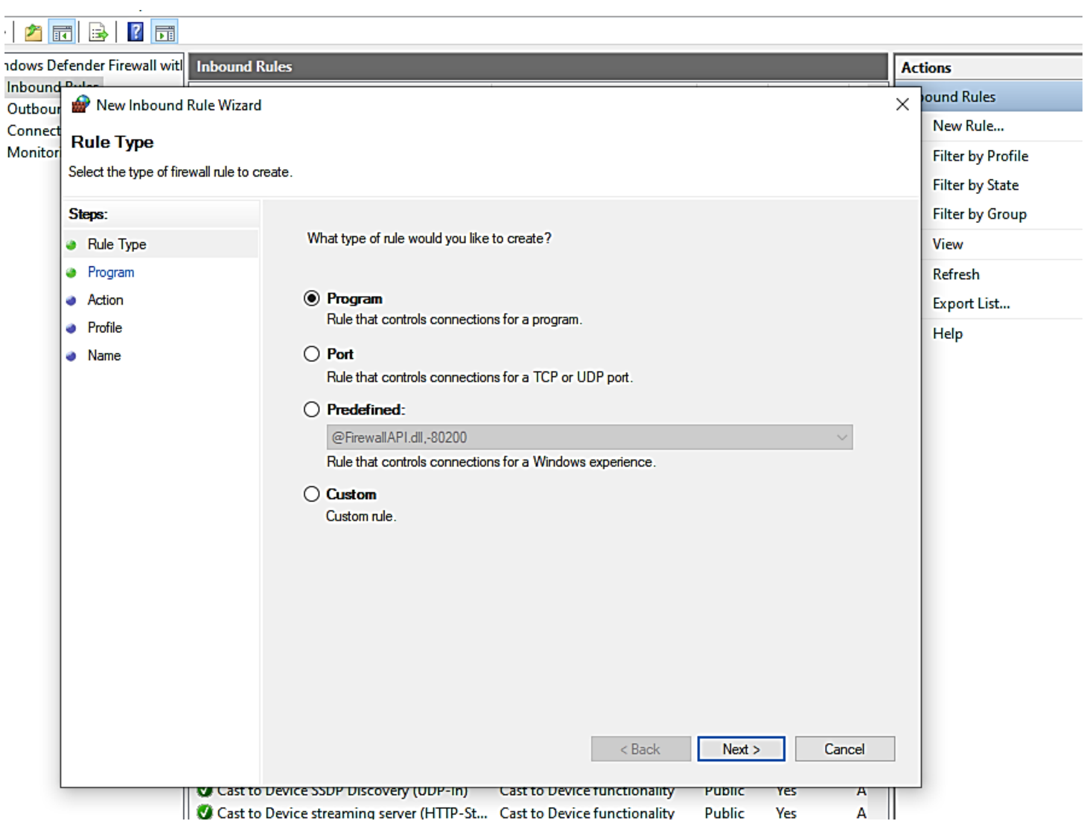
View and create firewall rules

Create firewall rules to allow or block connections to specified programs or ports. You can also allow a connection if it is authenticated, or if it comes from an authorized user, group, or computer. By default, inbound connections are blocked unless they match a rule that allows them, and outbound connections are allowed unless they match a rule that blocks them.



Inbound Rules

Name	Group	Profile	Enabled	A
✓ C++ Application Development Framework		Public	Yes	A
✓ C++ Application Development Framework		Public	Yes	A
✓ Microsoft Office Outlook		Public	Yes	A
✓ Packet Tracer Executable		Public	Yes	A
✓ Packet Tracer Executable		Public	Yes	A
✓ packettracer6		Public	Yes	A
✓ packettracer6		Public	Yes	A
✓ Skype for Business		Public	Yes	A
✓ Skype for Business		Public	Yes	A
✓ Skype for Business UcMapi		Public	Yes	A
✓ Skype for Business UcMapi		Public	Yes	A
✓ Teamviewer Remote Control Application		Public	Yes	A
✓ Teamviewer Remote Control Application		Public	Yes	A
✓ Teamviewer Remote Control Service		Public	Yes	A
✓ Teamviewer Remote Control Service		Public	Yes	A
✓ @FirewallAPI.dll,-80201	@FirewallAPI.dll,-80200	All	Yes	A
✓ @FirewallAPI.dll,-80206	@FirewallAPI.dll,-80200	All	Yes	A
✓ ms-resource:ProductPkgDisplayName	{78E1CD88-49E3-476E-B926-...	Public	Yes	A
✓ ms-resource:ProductPkgDisplayName	{78E1CD88-49E3-476E-B926-...	Public	Yes	A
✓ ms-resource:ProductPkgDisplayName	{78E1CD88-49E3-476E-B926-...	Private	Yes	A
✓ ms-resource:ProductPkgDisplayName	{78E1CD88-49E3-476E-B926-...	Private	Yes	A
✓ AllJoyn Router (TCP-In)	AllJoyn Router	Domai...	Yes	A
✓ AllJoyn Router (UDP-In)	AllJoyn Router	Domai...	Yes	A
✓ App Installer	App Installer	Domai...	Yes	A
BranchCache Content Retrieval (HTTP-In)	BranchCache - Content Retr...	All	No	A
BranchCache Hosted Cache Server (HTTP...	BranchCache - Hosted Cach...	All	No	A
BranchCache Peer Discovery (WSD-In)	BranchCache - Peer Discove...	All	No	A
✓ Cast to Device functionality (qWave-TCP...	Cast to Device functionality	Private...	Yes	A
✓ Cast to Device functionality (qWave-UDP...	Cast to Device functionality	Private...	Yes	A
✓ Cast to Device SSDP Discovery (UDP-In)	Cast to Device functionality	Public	Yes	A
✓ Cast to Device streaming server (HTTP-St...	Cast to Device functionality	Public	Yes	A
✓ Cast to Device streaming server (HTTP-St...	Cast to Device functionality	Domain	Yes	A


New Inbound Rule Wizard

Rule Type

Select the type of firewall rule to create.

Steps:
- Rule Type
- Program
- Action
- Profile
- Name

What type of rule would you like to create?

- (●) **Program** — Rule that controls connections for a program.
- ( ) **Port** — Rule that controls connections for a TCP or UDP port.
- ( ) **Predefined:** @FirewallAPI.dll,-80200 — Rule that controls connections for a Windows experience.
- ( ) **Custom** — Custom rule.

Cast to Device SSDP Discovery (UDP-In) Cast to Device functionality Public Yes A
Cast to Device streaming server (HTTP-St... Cast to Device functionality Public Yes A

IX. Precautions

1. Always test rules before applying them in production systems.
2. Ensure essential services (like SSH or RDP) are not permanently blocked.
3. Keep a backup of existing firewall configurations.
4. Avoid disabling the firewall unless absolutely necessary.

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. What is the purpose of a firewall in a network?
2. Differentiate between hardware and software firewalls.
3. Write any two advantages of a stateful firewall.
4. List the steps to allow or block a specific port in Windows Firewall.

Space for Answer:

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XI. Exercise

1. Configure a rule to block all incoming ICMP (ping) requests.
2. Create a rule to allow only port 443 (HTTPS) communication.
3. Compare the operation of Windows Firewall and Linux UFW using command outputs.

XII. References / Suggestions for further reading

1. Stallings, W. Cryptography and Network Security: Principles and Practice.
2. Kahate, A. Cryptography and Network Security.
3. NPTEL Course: Introduction to Information Security.
4. Microsoft Documentation: Windows Defender Firewall with Advanced Security.
5. Ubuntu Documentation: UFW — Uncomplicated Firewall.

XIII. Assessment schemes

Performance Indicators		Weightage
Process related (15 Marks)		**60 %**
1	Correct configuration of firewall rules on chosen OS	20 %
2	Testing and verifying allowed and blocked connections	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Correctness and effectiveness of firewall settings	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			Dated Signature of Teacher
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 15: Send a Test Mail Securely using any Open-source Tool (Example – Pretty Good Privacy with GnuPG).

I. Practical Significance

This practical introduces email security mechanisms using Pretty Good Privacy (PGP) or GNU Privacy Guard (GnuPG) to ensure confidentiality, integrity, and authenticity of email communication. Students will learn how to encrypt, decrypt, sign, and verify emails using public and private key pairs. The experiment helps in understanding how cryptographic protection safeguards emails from eavesdropping and tampering.

II. Industry / Employer Expected Outcome

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO5 – Apply security on Network and Database.

IV. Laboratory Learning Outcome (LLO)

LLO 15.1: Implement email security.

V. Relevant Affective domain related Outcomes(s)

1. Responsibility**:** Apply correct encryption practices while handling confidential information.
2. Ethical Awareness**:** Recognize the importance of secure and authentic digital communication.
3. Analytical Skills**:** Verify message authenticity and understand key-based security mechanisms.

VI. Theoretical Background

Email security is the practice of protecting email content and user accounts against unauthorized access, loss, or compromise.

PGP (Pretty Good Privacy) and **GnuPG (GNU Privacy Guard)** are encryption programs that use a combination of **symmetric** and **asymmetric cryptography** to secure email communication.

Working of PGP/GnuPG:

1. **Key Generation:** Each user generates a pair of keys — a **public key** (shared) and a **private key** (kept secret).
2. **Encryption:** The sender encrypts the message using the receiver's public key.
3. **Decryption:** The receiver decrypts the message using their private key.
4. **Digital Signature:** The sender signs the message with their private key to ensure authenticity.
5. **Verification:** The receiver verifies the signature using the sender's public key.

Email Security Features:

- **Confidentiality:** Message encryption ensures only the intended recipient can read it.
- **Integrity:** Digital signatures ensure the message has not been altered.
- **Authentication:** Verifies sender identity using key-based signing.

- **Non-repudiation:** Sender cannot deny sending the signed message.

Common Tools:

- GnuPG (command-line tool)
- Mozilla Thunderbird with Enigmail plugin
- PGP Desktop

VII. Resources required

Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows 10 / 11 / Linux (Ubuntu/CentOS)		
3	Tools / Software Required	GnuPG / PGP / Thunderbird with Enigmail		

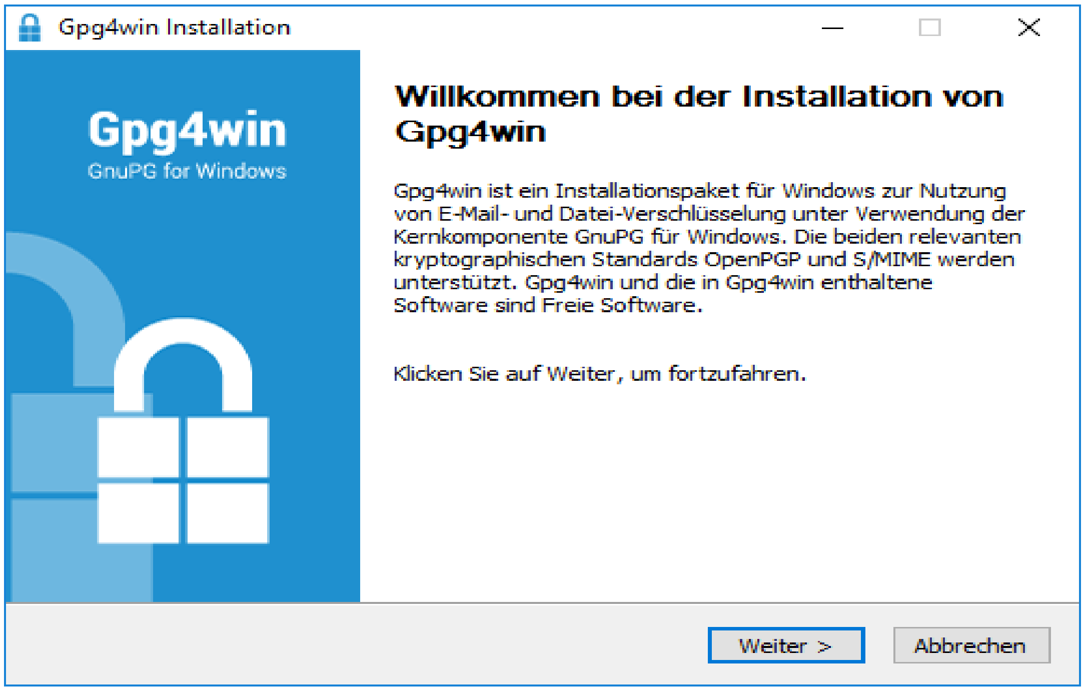
VIII. Procedure

Step-by-Step Procedure

Step 1:

To install GPG on Windows, download and install the **"Kleopatra"** application from:
https://www.gpg4win.org/download.html

After installation, **start the Kleopatra application.**



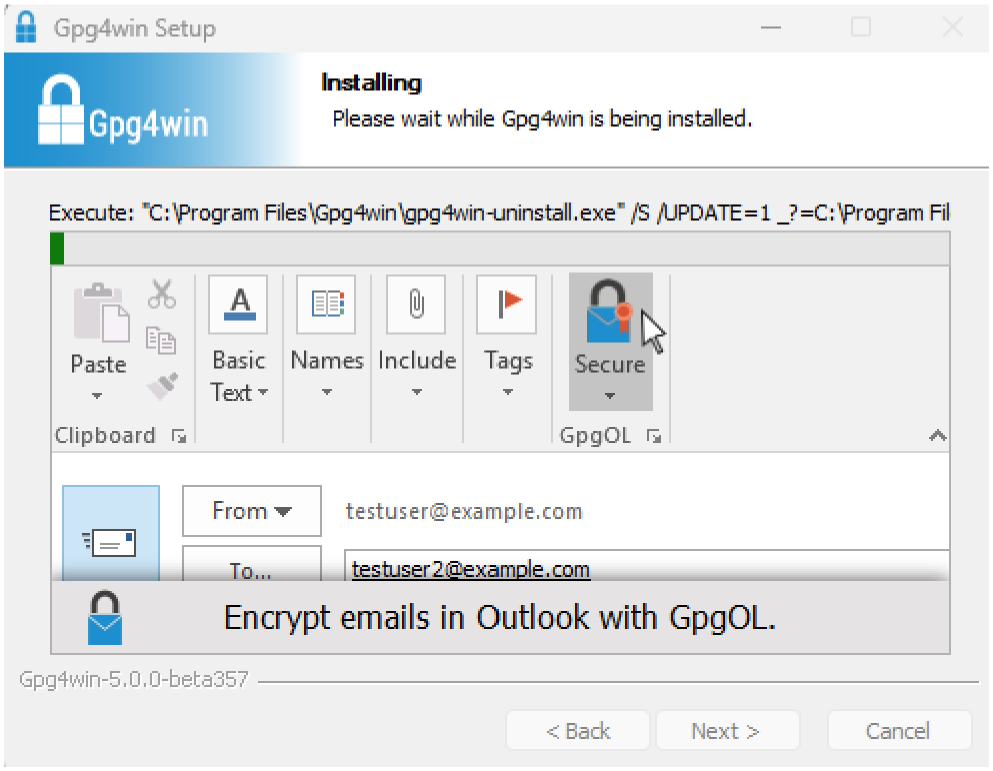
Willkommen bei der Installation von Gpg4win

Gpg4win ist ein Installationspaket für Windows zur Nutzung von E-Mail- und Datei-Verschlüsselung unter Verwendung der Kernkomponente GnuPG für Windows. Die beiden relevanten kryptographischen Standards OpenPGP und S/MIME werden unterstützt. Gpg4win und die in Gpg4win enthaltene Software sind Freie Software.

Klicken Sie auf Weiter, um fortzufahren.

Step 2:

After launching the installer, click on **Next** to continue.


Gpg4win Setup

Installing

Please wait while Gpg4win is being installed.

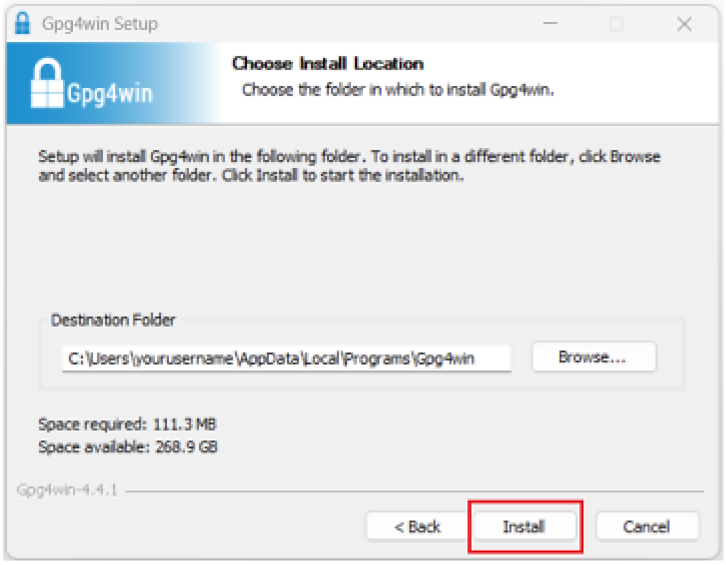
Execute: "C:\Program Files\Gpg4win\gpg4win-uninstall.exe" /S /UPDATE=1 _?=C:\Program Fil

Step 3:

Specify the **destination folder path** for installation.

You can browse and select the desired path.

Click on **Install** after confirming the folder path.


Gpg4win Setup

Choose Install Location

Choose the folder in which to install Gpg4win.

Setup will install Gpg4win in the following folder. To install in a different folder, click Browse and select another folder. Click Install to start the installation.

Destination Folder

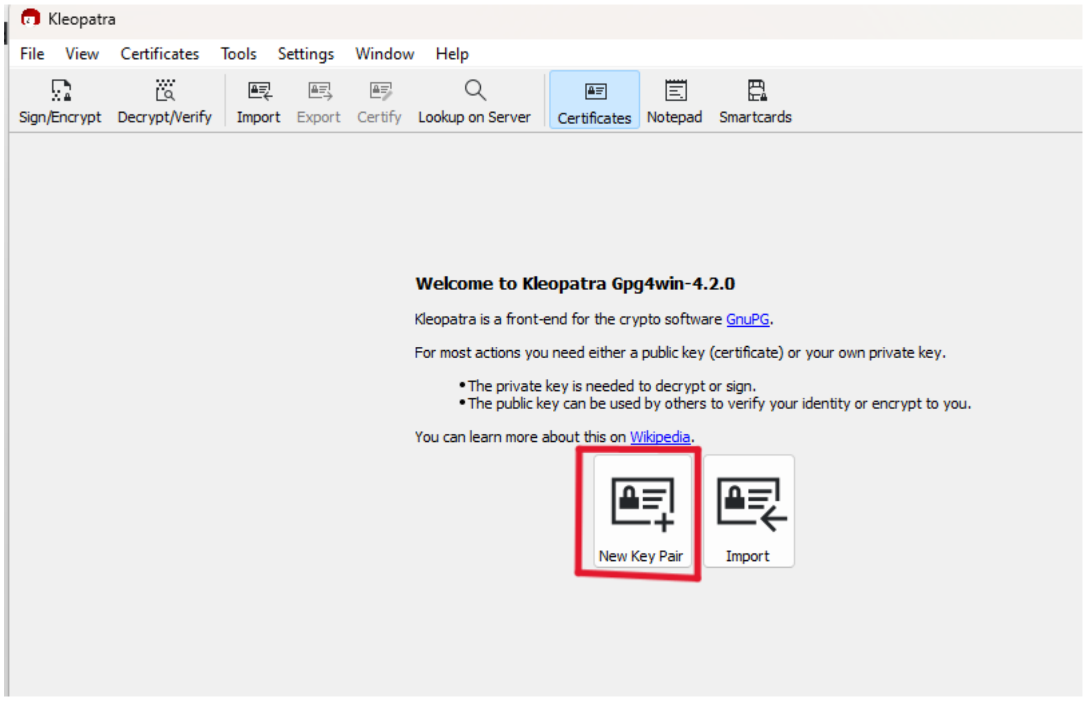
C:\Users\yourusername\AppData\Local\Programs\Gpg4win

Space required: 111.3 MB

Space available: 268.9 GB

Step 4:

After successful installation, the **welcome page** of the Kleopatra application will appear.



Kleopatra
File View Certificates Tools Settings Window Help
Sign/Encrypt Decrypt/Verify Import Export Certify Lookup on Server Certificates Notepad Smartcards
New Key Pair
Import

Welcome to Kleopatra Gpg4win-4.2.0

Kleopatra is a front-end for the crypto software GnuPG.

For most actions you need either a public key (certificate) or your own private key.

- The private key is needed to decrypt or sign.
- The public key can be used by others to verify your identity or encrypt to you.

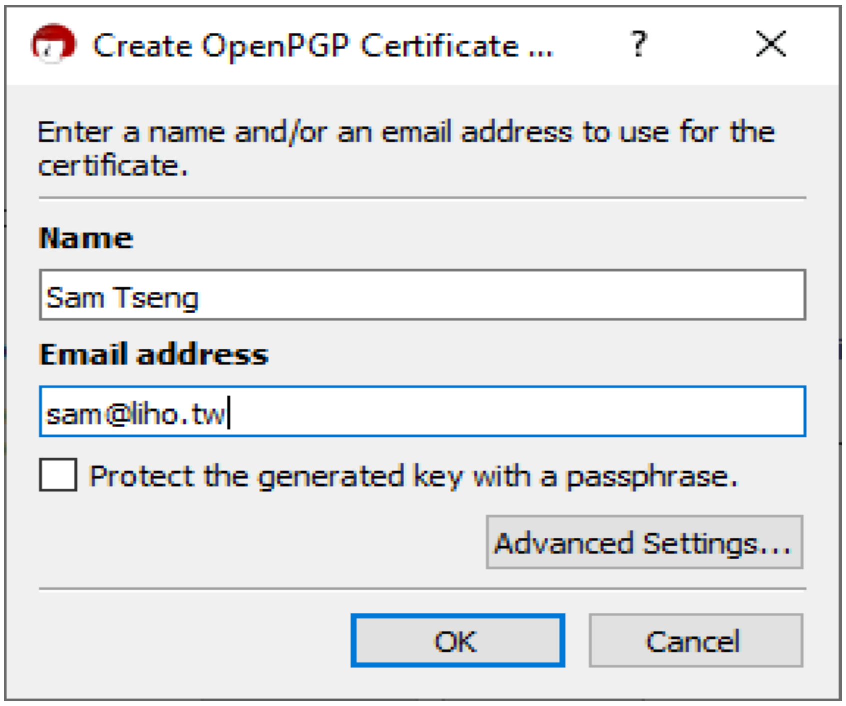
You can learn more about this on Wikipedia.

Step 5 (Key Generation):

On the welcome screen, click on **"Certificates"** option.

Select **"Create OpenPGP Certificate."**

Enter your **Name** and **Email Address**, then click on **"Advanced Settings…"** to open key configuration options.



Enter a name and/or an email address to use for the certificate.

Name

Sam Tseng

Email address

sam@liho.tw

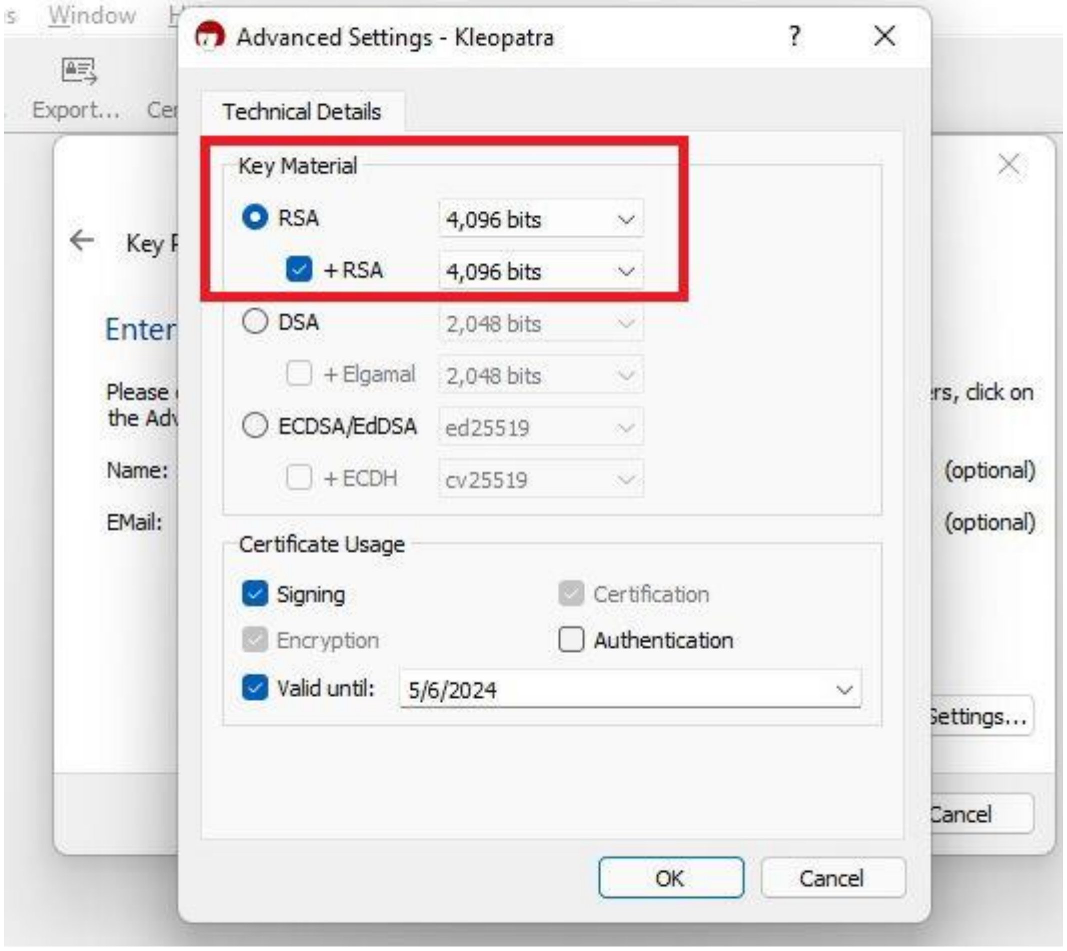
☐ Protect the generated key with a passphrase.

Step 6:

Provide additional key generation settings such as:

- Key type (RSA, ECC, etc.)
- Key size
- Expiration date

Click **OK** to proceed.



Advanced Settings - Kleopatra

Technical Details

Key Material

RSA: 4,096 bits
+ RSA: 4,096 bits
DSA: 2,048 bits
+ Elgamal: 2,048 bits
ECDSA/EdDSA: ed25519
+ ECDH: cv25519

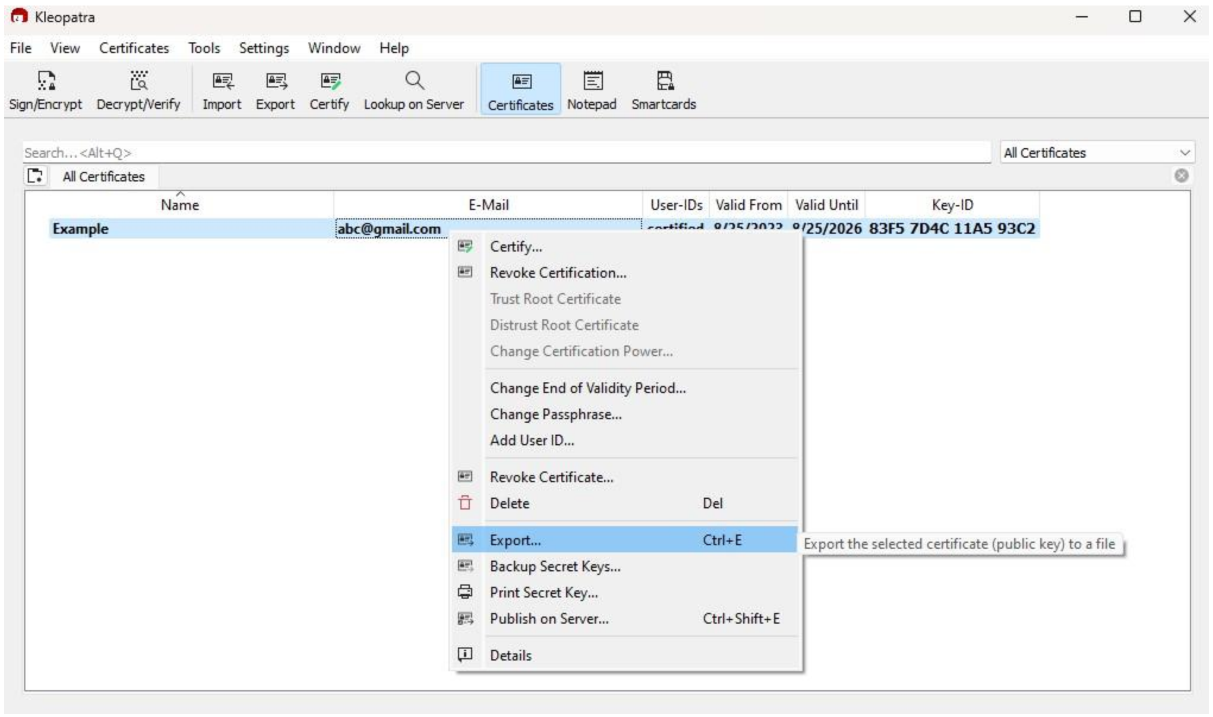
Certificate Usage

Signing ✓ | Certification ✓
Encryption ✓ | Authentication
Valid until: ✓ 5/6/2024

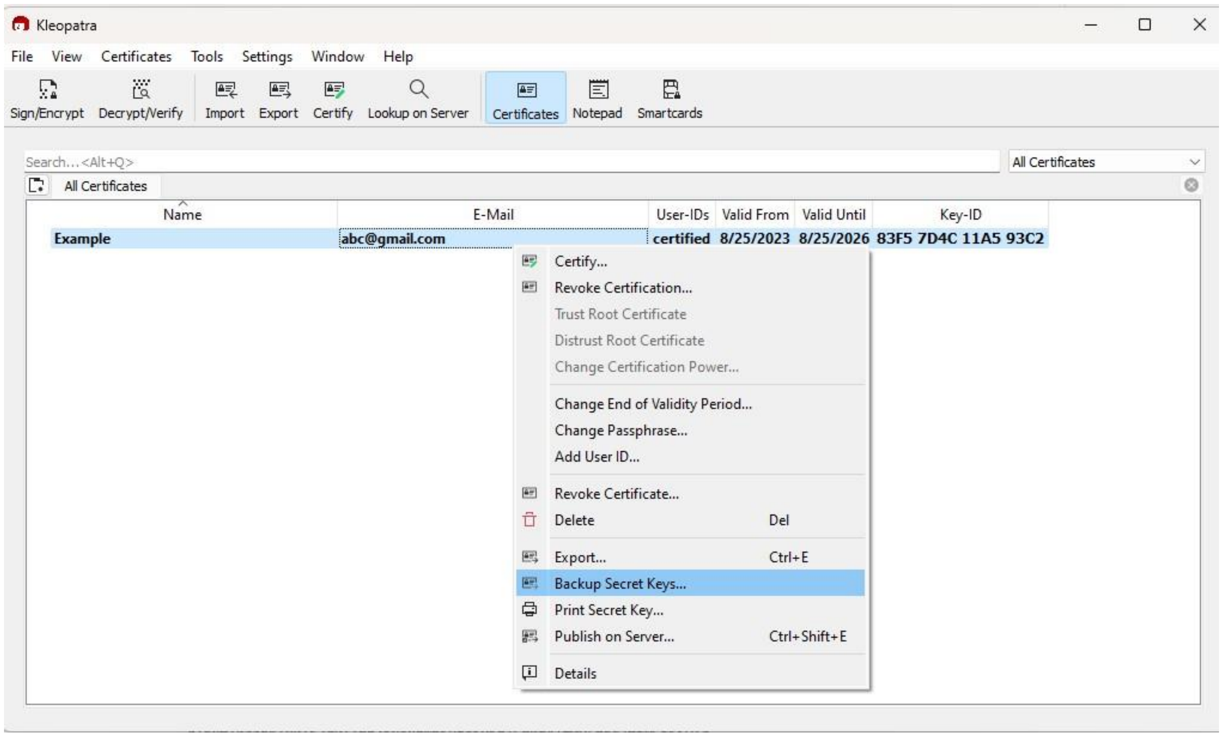
Step 7 (Export Public Key):

Once key generation is completed, a certificate is created containing **Name, Email, User ID, Validity, and Key ID**.

Select the created certificate → right-click on your name → choose **“Export…”** or press **Ctrl + E** to export the public key.

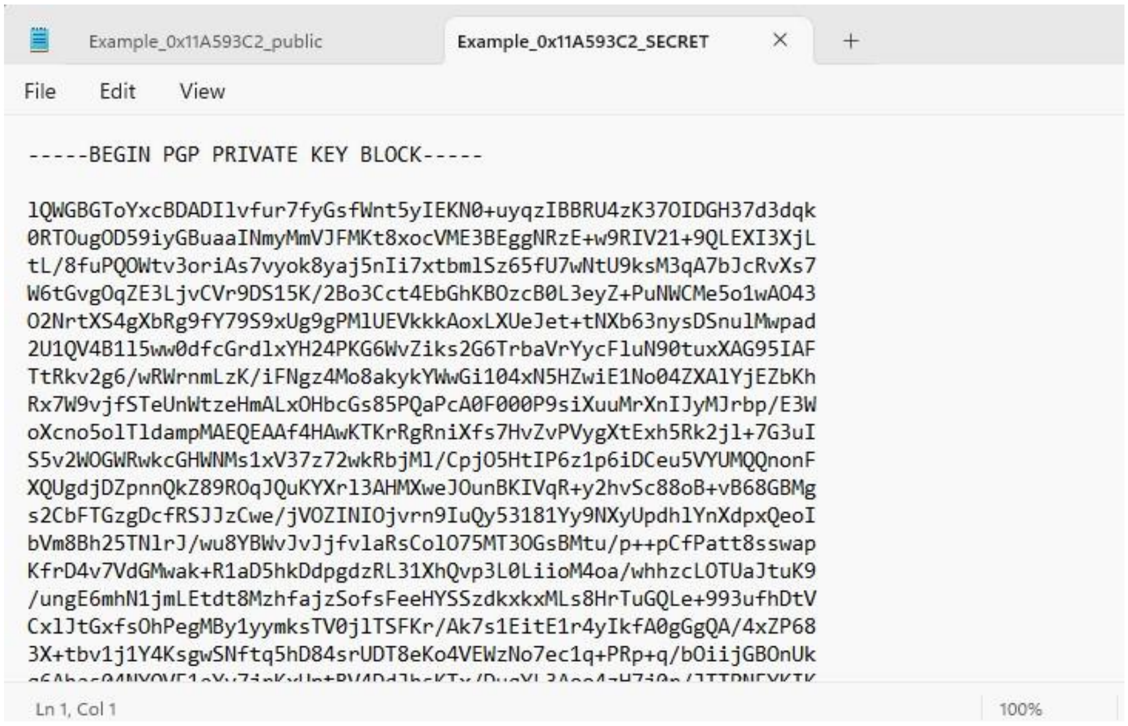

Kleopatra
File View Certificates Tools Settings Window Help
Sign/Encrypt Decrypt/Verify Import Export Certify Lookup on Server Certificates Notepad Smartcards
Search...<Alt+Q>
All Certificates
Name E-Mail User-IDs Valid From Valid Until Key-ID
Example abc@gmail.com certified 8/25/2023 8/25/2026 83F5 7D4C 11A5 93C2
Certify...
Revoke Certification...
Trust Root Certificate
Distrust Root Certificate
Change Certification Power...
Change End of Validity Period...
Change Passphrase...
Add User ID...
Revoke Certificate...
Delete Del
Export... Ctrl+E
Backup Secret Keys...
Print Secret Key...
Publish on Server... Ctrl+Shift+E
Details
Export the selected certificate (public key) to a file

Step 8 (Backup Private Key):
Click on the **Email field** and select **“Backup Security Keys…”** from the dropdown list. This step backs up your private key safely.


Kleopatra
File View Certificates Tools Settings Window Help
Sign/Encrypt Decrypt/Verify Import Export Certify Lookup on Server Certificates Notepad Smartcards
Search...<Alt+Q>
All Certificates
Name E-Mail User-IDs Valid From Valid Until Key-ID
Example abc@gmail.com certified 8/25/2023 8/25/2026 83F5 7D4C 11A5 93C2
Certify...
Revoke Certification...
Trust Root Certificate
Distrust Root Certificate
Change Certification Power...
Change End of Validity Period...
Change Passphrase...
Add User ID...
Revoke Certificate...
Delete Del
Export... Ctrl+E
Backup Secret Keys...
Print Secret Key...
Publish on Server... Ctrl+Shift+E
Details

Step 9:

Copy the **exported public key** and save it into a new .txt file.

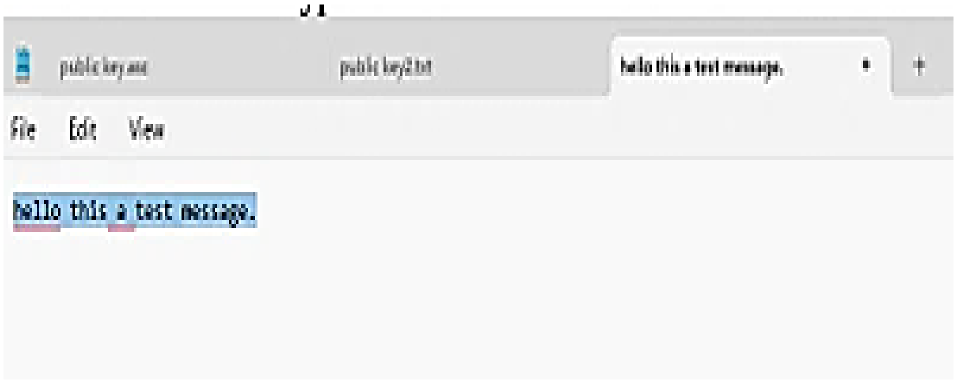


```
-----BEGIN PGP PRIVATE KEY BLOCK-----

lQWGBGToYxcBDADIlvfur7fyGsfWnt5yIEKN0+uyqzIBBRU4zK37OIDGH37d3dqk
0RTOugOD59iyGBuaaINmyMmVJFMKt8xocVME3BEggNRzE+w9RIV21+9QLEXI3XjL
tL/8fuPQOWtv3oriAs7vyok8yaj5nIi7xtbmlSz65fU7wNtU9ksM3qA7bJcRvXs7
W6tGvgOqZE3LjvCVr9DS15K/2Bo3Cct4EbGhKBOzcB0L3eyZ+PuNWCMe5o1wAO43
O2NrtXS4gXbRg9fY79S9xUg9gPMlUEVkkkAoxLXUeJet+tNXb63nysDSnulMwpad
2U1QV4B1l5ww0dfcGrdlxYH24PKG6WvZiks2G6TrbaVrYycFluN90tuxXAG95IAF
TtRkv2g6/wRWrnmLzK/iFNgz4Mo8akykYWwGi104xN5HZwiE1No04ZXAlYjEZbKh
Rx7W9vjfSTeUnWtzeHmALxOHbcGs85PQaPcA0F000P9siXuuMrXnIJyMJrbp/E3W
oXcno5olTldampMAEQEAAf4HAwKTKrRgRniXfs7HvZvPVygXtExh5Rk2jl+7G3uI
S5v2WOGWRwkcGHWNMs1xV37z72wkRbjMl/CpjO5HtIP6z1p6iDCeu5VYUMQQnonF
XQUgdjDZpnnQkZ89ROqJQuKYXrl3AHMXweJOunBKIVqR+y2hvSc88oB+vB68GBMg
s2CbFTGzgDcfRSJJzCwe/jVOZINIOjvrn9IuQy53181Yy9NXyUpdhlYnXdpxQeoI
bVm8Bh25TNlrJ/wu8YBWvJvJjfvlaRsColO75MT3OGsBMtu/p++pCfPatt8sswap
KfrD4v7VdGMwak+R1aD5hkDdpgdzRL31XhQvp3L0LiioM4oa/whhzcLOTUaJtuK9
/ungE6mhN1jmLEtdt8MzhfajzSofsFeeHYSSzdkxkxMLs8HrTuGQLe+993ufhDtV
CxlJtGxfsOhPegMBy1yymksTV0jlTSFKr/Ak7s1EitE1r4yIkfA0gGgQA/4xZP68
3X+tbv1j1Y4KsgwSNftq5hD84srUDT8eKo4VEWzNo7ec1q+PRp+q/bOiijGBOnUk
```

Step 10:

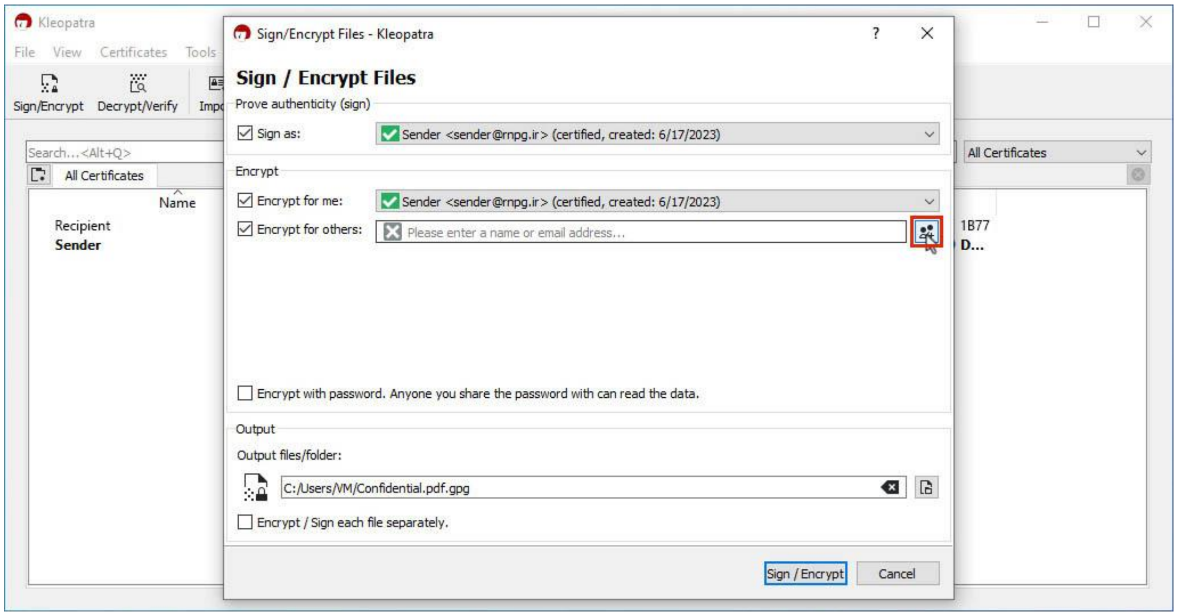
Create a **demo file** (e.g., message.txt) containing the text you wish to encrypt.



hello this a test message.

Step 11:

In Kleopatra, select your **public key** for encryption.


Kleopatra
File View Certificates Tools
Sign/Encrypt Decrypt/Verify Impo
Search...<Alt+Q>
All Certificates
Name
Recipient
Sender
All Certificates
1B77
D...
Sign/Encrypt Files - Kleopatra

Sign / Encrypt Files

Prove authenticity (sign)

☑ Sign as: Sender <sender@rnpg.ir> (certified, created: 6/17/2023)

Encrypt

☑ Encrypt for me: Sender <sender@rnpg.ir> (certified, created: 6/17/2023)

☑ Encrypt for others: Please enter a name or email address...

☐ Encrypt with password. Anyone you share the password with can read the data.

Output

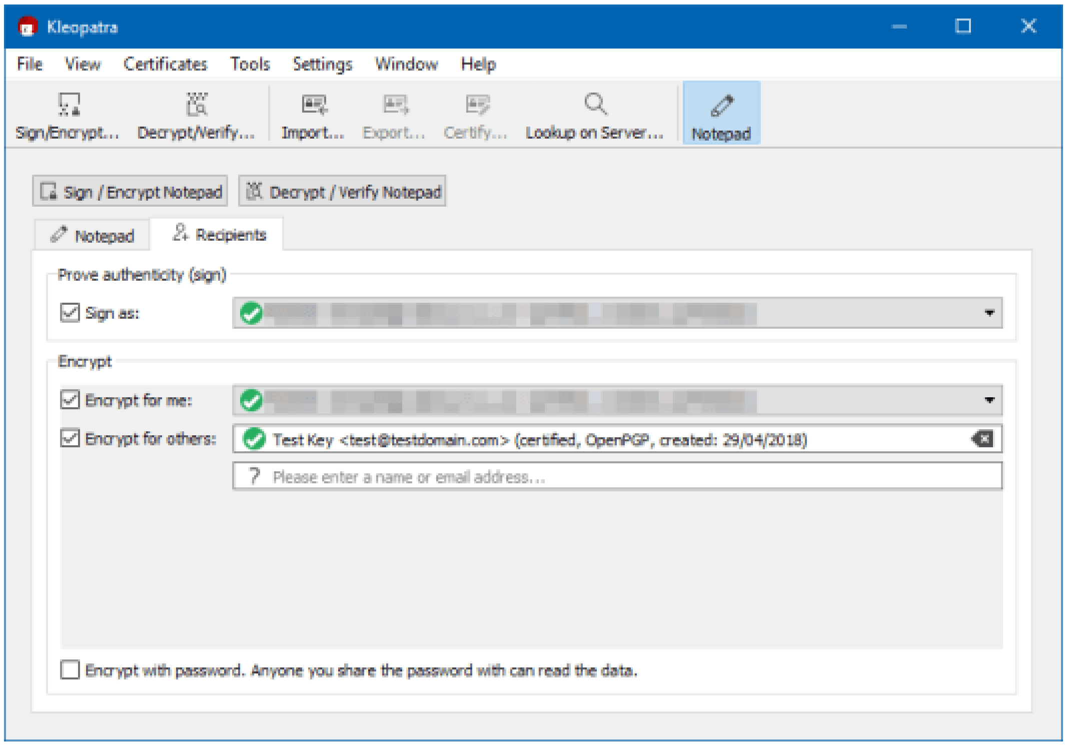
Output files/folder: C:/Users/VM/Confidential.pdf.gpg

☐ Encrypt / Sign each file separately.

Step 12:

Optionally, you can also **sign** the file using your email ID for authenticity.

Once all information is filled, click on **“Sign/Encrypt”** button.


Kleopatra
File View Certificates Tools Settings Window Help
Sign/Encrypt... Decrypt/Verify... Import... Export... Certify... Lookup on Server... Notepad
Sign / Encrypt Notepad
Decrypt / Verify Notepad
Notepad
Recipients

Prove authenticity (sign)

☑ Sign as:

Encrypt

☑ Encrypt for me:

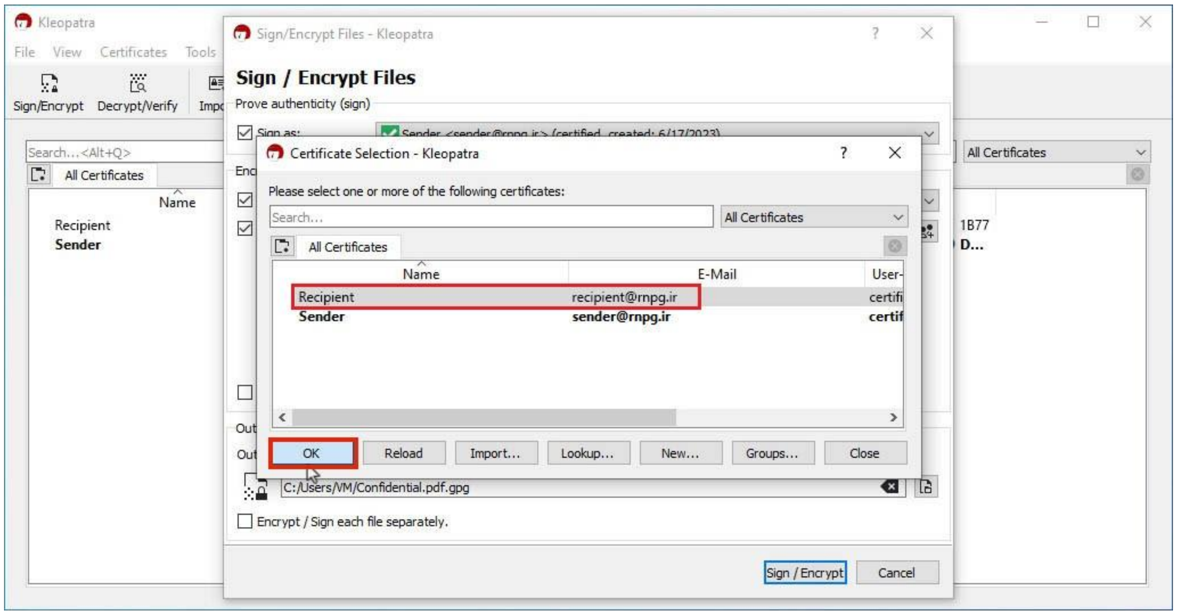
☑ Encrypt for others: Test Key <test@testdomain.com> (certified, OpenPGP, created: 29/04/2018)

Please enter a name or email address...

☐ Encrypt with password. Anyone you share the password with can read the data.

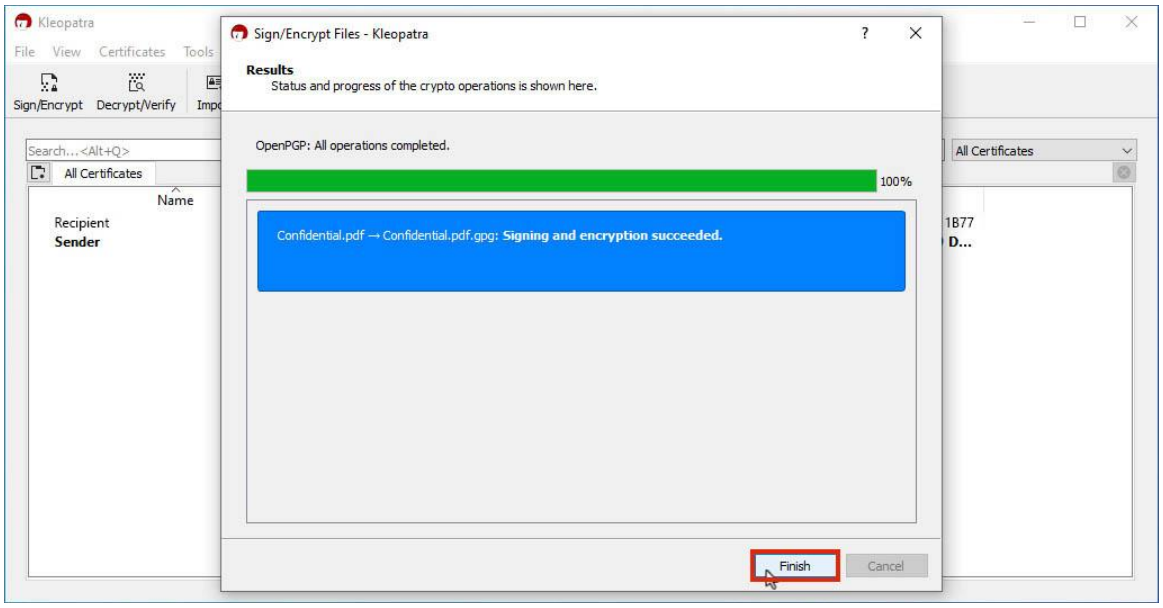
Step 13:

Select one or more **certificates** if required for encryption.


Kleopatra
File View Certificates Tools
Sign/Encrypt Decrypt/Verify
Sign / Encrypt Files
Prove authenticity (sign)
Certificate Selection - Kleopatra
Please select one or more of the following certificates:
All Certificates
Name E-Mail
Recipient recipient@rnpg.ir
Sender sender@rnpg.ir
OK Reload Import... Lookup... New... Groups... Close
C:/Users/VM/Confidential.pdf.gpg
Encrypt / Sign each file separately.
Sign / Encrypt Cancel

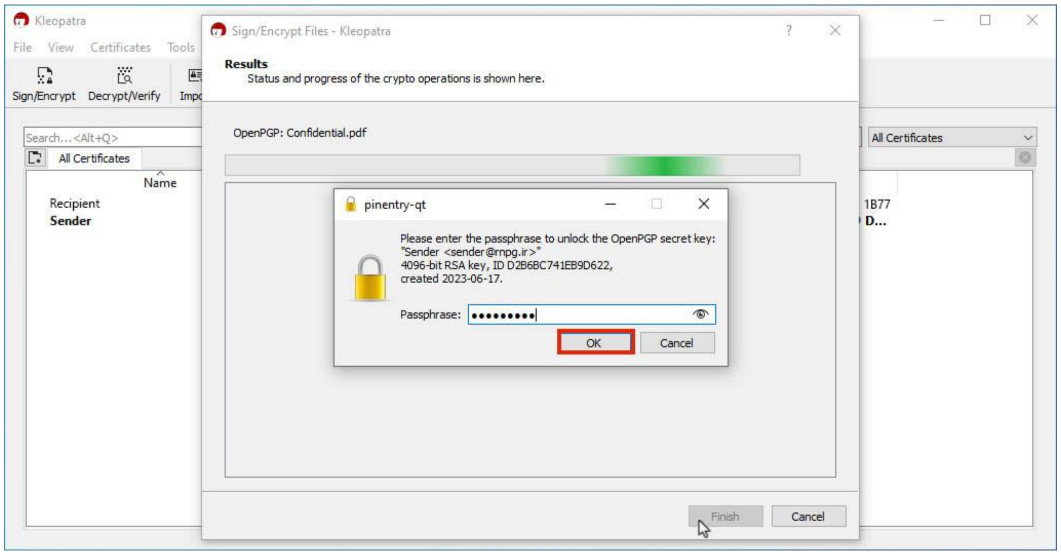
Step 14:

Wait until all encryption operations are completed successfully.


Sign/Encrypt Files - Kleopatra
Results
Status and progress of the crypto operations is shown here.
OpenPGP: All operations completed.
100%
Confidential.pdf → Confidential.pdf.gpg: Signing and encryption succeeded.
Finish Cancel

Step 15:

Enter your **key password (passphrase)** when prompted, to authorize the encryption or decryption process.


Kleopatra
File View Certificates Tools
Sign/Encrypt Decrypt/Verify
Sign/Encrypt Files - Kleopatra
Results
OK
Cancel
Finish

Status and progress of the crypto operations is shown here.

OpenPGP: Confidential.pdf

pinentry-qt

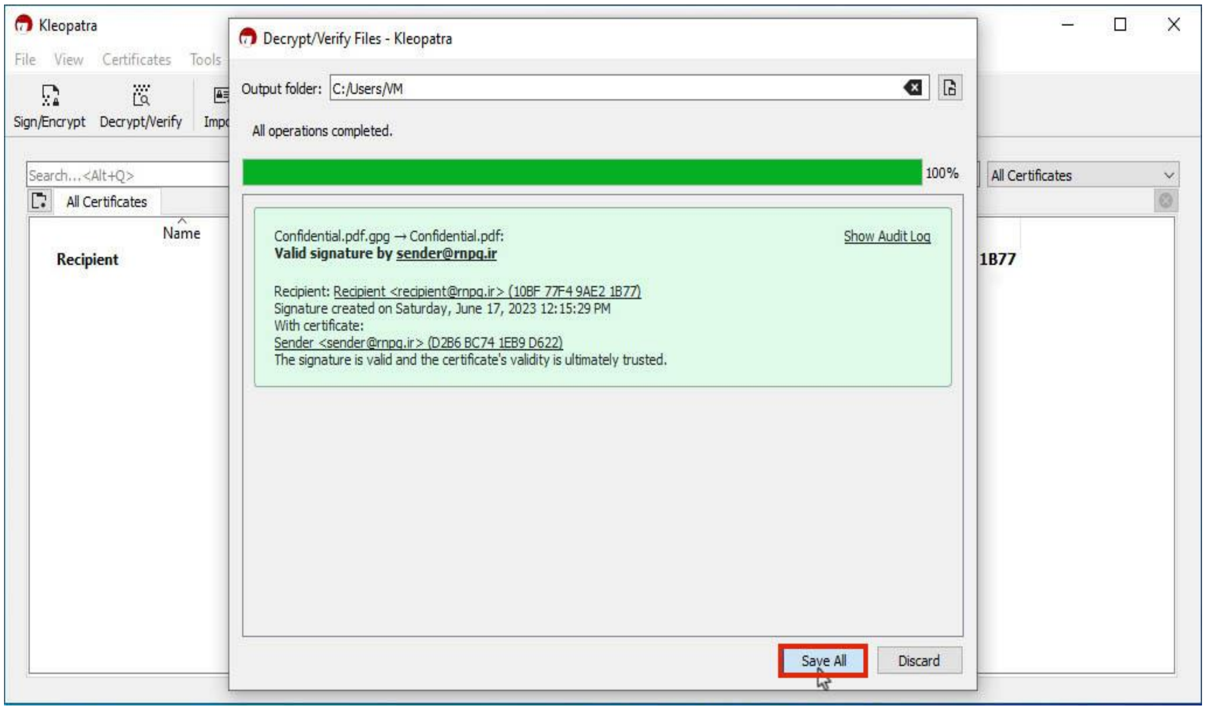
Please enter the passphrase to unlock the OpenPGP secret key:
"Sender <sender@rnpg.ir>"
4096-bit RSA key, ID D2B6BC741EB9D622,
created 2023-06-17.

Passphrase: •••••••••

Step 16 (Decryption):

To decrypt, select **Decrypt/Verify** option from the toolbar.

Browse and select the **encrypted file** you want to decrypt.


Kleopatra
File View Certificates Tools
Sign/Encrypt Decrypt/Verify
Decrypt/Verify Files - Kleopatra
Show Audit Log
Save All
Discard

Output folder: C:/Users/VM

All operations completed.

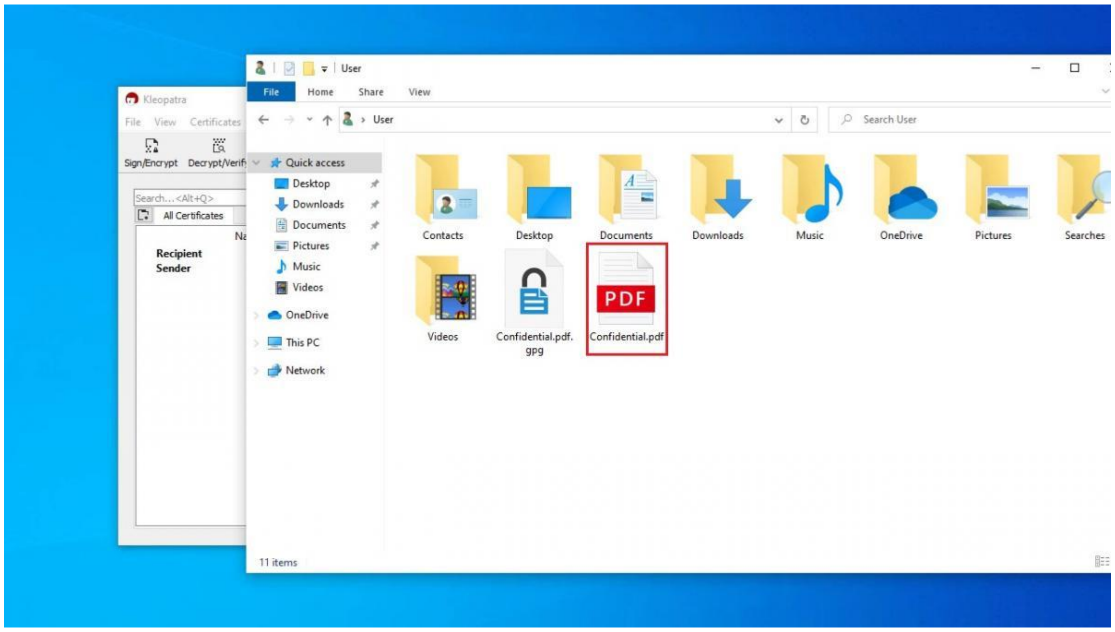
100%

Confidential.pdf.gpg → Confidential.pdf:
Valid signature by sender@rnpq.ir

Recipient: Recipient <recipient@rnpq.ir> (10BF 77F4 9AE2 1B77)
Signature created on Saturday, June 17, 2023 12:15:29 PM
With certificate:
Sender <sender@rnpq.ir> (D2B6 BC74 1EB9 D622)
The signature is valid and the certificate's validity is ultimately trusted.

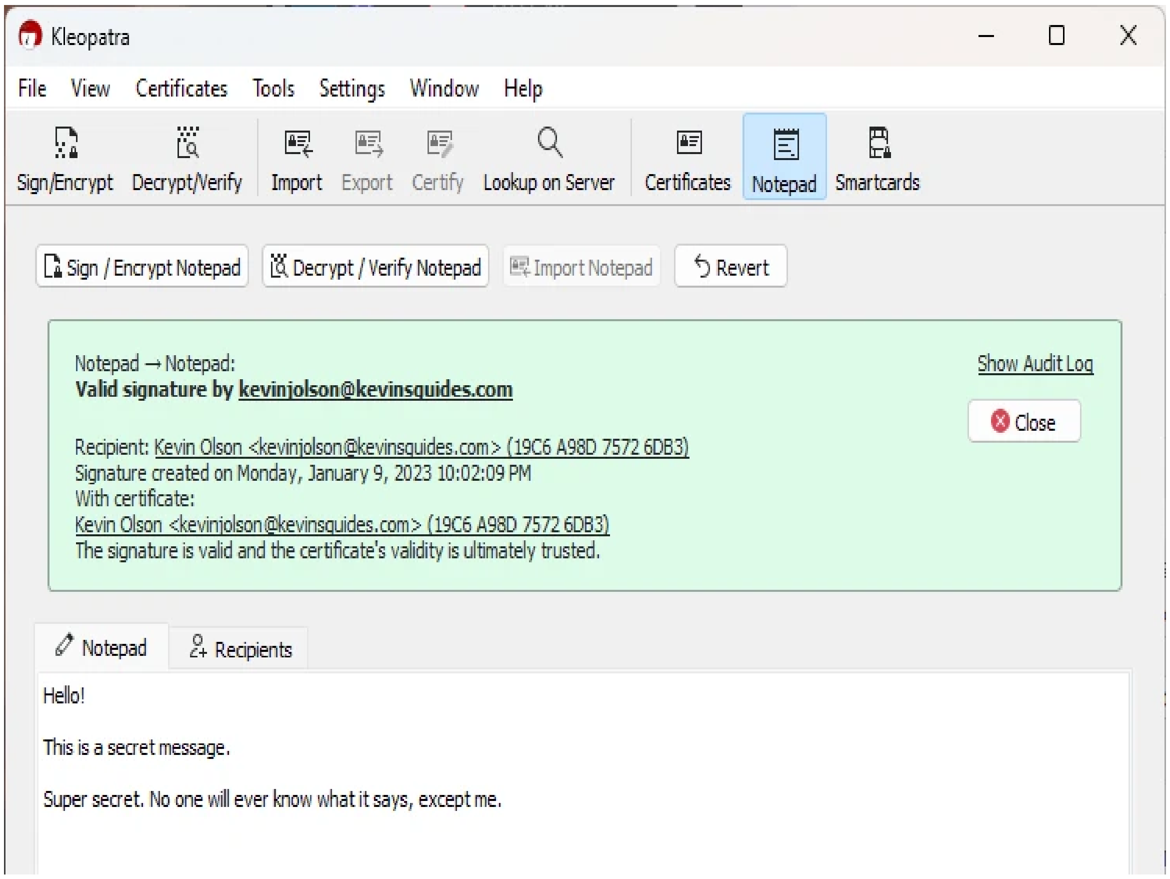
Step 17:

Confirm the selection of the encrypted file for decryption.



Step 18:

After successful decryption, the **original message** will be displayed.



Notepad → Notepad:
Valid signature by kevinjolson@kevinsguides.com

Recipient: Kevin Olson <kevinjolson@kevinsguides.com> (19C6 A98D 7572 6DB3)
Signature created on Monday, January 9, 2023 10:02:09 PM
With certificate:
Kevin Olson <kevinjolson@kevinsguides.com> (19C6 A98D 7572 6DB3)
The signature is valid and the certificate's validity is ultimately trusted.

Hello!

This is a secret message.

Super secret. No one will ever know what it says, except me.

IX. Precautions

1. Keep your **private key confidential** and protected with a strong passphrase.
2. Always verify the authenticity of a contact’s public key before using it.
3. Backup your keys in a secure location.
4. Do not use untrusted systems for encryption or signing activities.

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. What is the purpose of using PGP in email security?
2. Explain how public and private keys work in GnuPG.
3. What are the main security features provided by encrypted email communication?
4. Perform encryption and decryption of an email using GnuPG.
5. Explain the difference between signing and encrypting an email.

Space for Answer:

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

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XI. Exercise

1. Encrypt and send a sample message using GnuPG or Thunderbird.
2. Verify a signed message using the sender's public key.
3. Research and report the difference between PGP and S/MIME protocols.

XII. References / Suggestions for further reading

1. Stallings, W. Cryptography and Network Security: Principles and Practice.
2. Kahate, A. Cryptography and Network Security.
3. NPTEL Course: Introduction to Information Security.
4. GnuPG Official Website: https://gnupg.org
5. Thunderbird Enigmail Documentation: https://www.enigmail.net
6. Virtual Labs (IIIT Hyderabad): https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html

XIII. Assessment schemes

Performance Indicators		Weightage
Process related (15 Marks)		**60 %**
1	Correct generation and sharing of public/private keys	20 %
2	Successful encryption, signing, and decryption of email	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Accuracy of encrypted/decrypted message	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	

Practical No. 16: Find the Origin of an Email using Email Tracker Pro

I. Practical Significance

This practical introduces email tracing and analysis techniques using Email Tracker Pro, a tool that helps identify the origin, sender's IP address, location, and route taken by an email. Students will learn how to analyze email headers to detect spam, phishing, or spoofed emails, and understand how tracing contributes to cyber forensics and incident response.

II. Industry / Employer Expected Outcome

The aim of this course is to help the students to attain the following Industry Identified Outcomes through various teaching learning experiences: Implement policies and guidelines to maintain data security and privacy during data transmission.

III. Course Level Learning Outcomes(s)

CO5 – Apply security on Network and Database.

IV. Laboratory Learning Outcome (LLO)

LLO 16.1: Use of email tracker pro.

V. Relevant Affective domain related Outcomes(s)

1. Responsibility: Use tracking tools ethically and only for legitimate analysis.
2. Ethical Awareness: Understand privacy implications and lawful use of tracking tools.
3. Analytical Skills: Interpret header data and identify key routing details.

VI. Theoretical Background

Email tracing is a process used to determine the path and origin of an email message. Every email sent across the Internet carries a header containing metadata — such as sender and recipient information, IP addresses, time stamps, and mail server details.

Email Tracker Pro is a Windows-based utility that automatically reads and analyzes these headers to provide insights like:

- **Sender's IP address**
- **Approximate geographical location**
- **Mail transfer route (Received path)**
- **Email client and server information**

Structure of an Email Header:

An email header typically includes lines such as:

```
Received: from mail.example.com (123.45.67.89)
by smtp.gmail.com with ESMTP id abc123;
Mon, 6 Oct 2025 10:12:34 +0530
```

Here, the **IP address (123.45.67.89)** can be used to trace the sender's network origin.

Uses of Email Tracing:

- Detecting **spam or phishing** sources.
- Verifying sender authenticity.
- Supporting **digital forensics investigations**.
- Tracking **cybercrime evidence**.

VII. Resources required

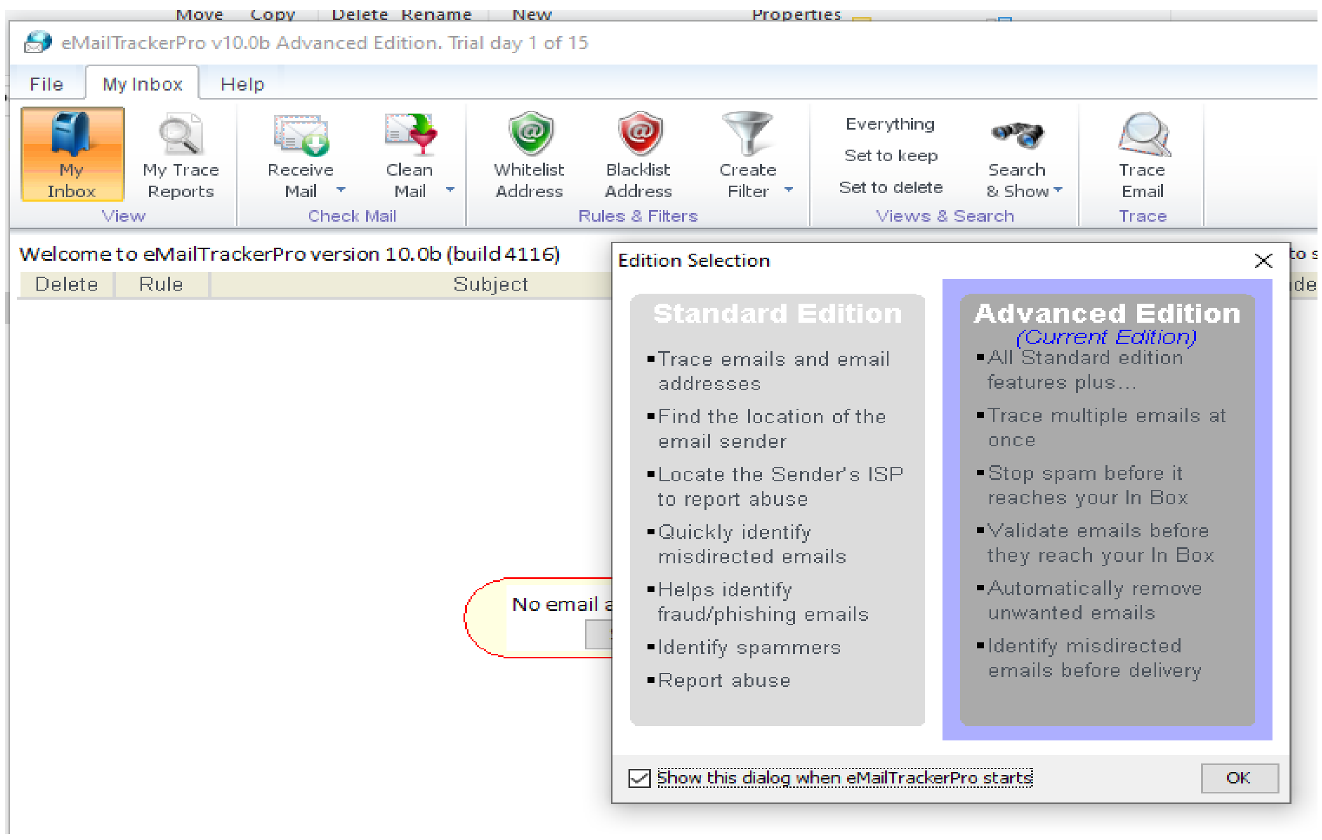
Sr. No.	Name of Resources	Specifications	Quantity	Remarks
1	Hardware: Computer Systems	Computer (i3 – i5 RAM minimum 2 GB and onwards and HDD minimum 10 GB	As per batch Size	--
2	Operating System	Windows 10 / 11 / Linux (Ubuntu/CentOS)		
3	Tools / Software Required	Email Tracker Pro (Free or Trial Version)		

VIII. Procedure

Step-by-Step Procedure

Step 1:Launch Email Tracker Pro on your system.

Double-click the application icon or open it from the Start Menu.



Welcome to eMailTrackerPro version 10.0b (build 4116)

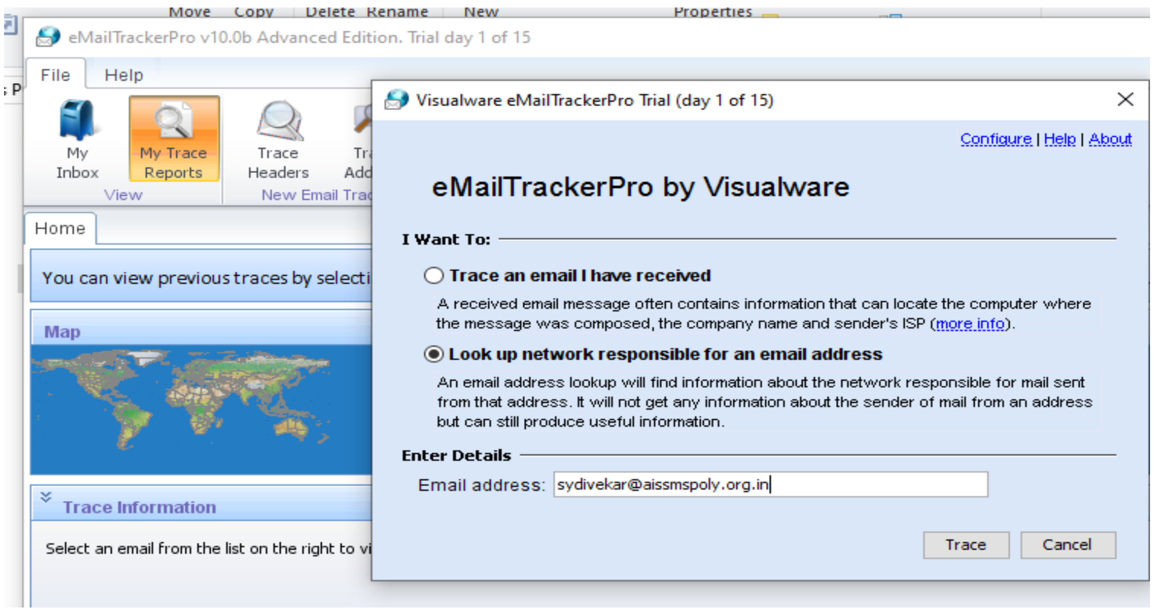
Edition Selection

Standard Edition
- Trace emails and email addresses
- Find the location of the email sender
- Locate the Sender's ISP to report abuse
- Quickly identify misdirected emails
- Helps identify fraud/phishing emails
- Identify spammers
- Report abuse

Advanced Edition *(Current Edition)*
- All Standard edition features plus...
- Trace multiple emails at once
- Stop spam before it reaches your In Box
- Validate emails before they reach your In Box
- Automatically remove unwanted emails
- Identify misdirected emails before delivery

☑ Show this dialog when eMailTrackerPro starts

Step 2: In the main window of Email Tracker Pro, click on **"Analyze Email Address."**



You can view previous traces by selecti

Select an email from the list on the right to vi

Visualware eMailTrackerPro Trial (day 1 of 15)

Configure | Help | About

eMailTrackerPro by Visualware

I Want To:

( ) Trace an email I have received

A received email message often contains information that can locate the computer where the message was composed, the company name and sender's ISP (more info).

(●) Look up network responsible for an email address

An email address lookup will find information about the network responsible for mail sent from that address. It will not get any information about the sender of mail from an address but can still produce useful information.

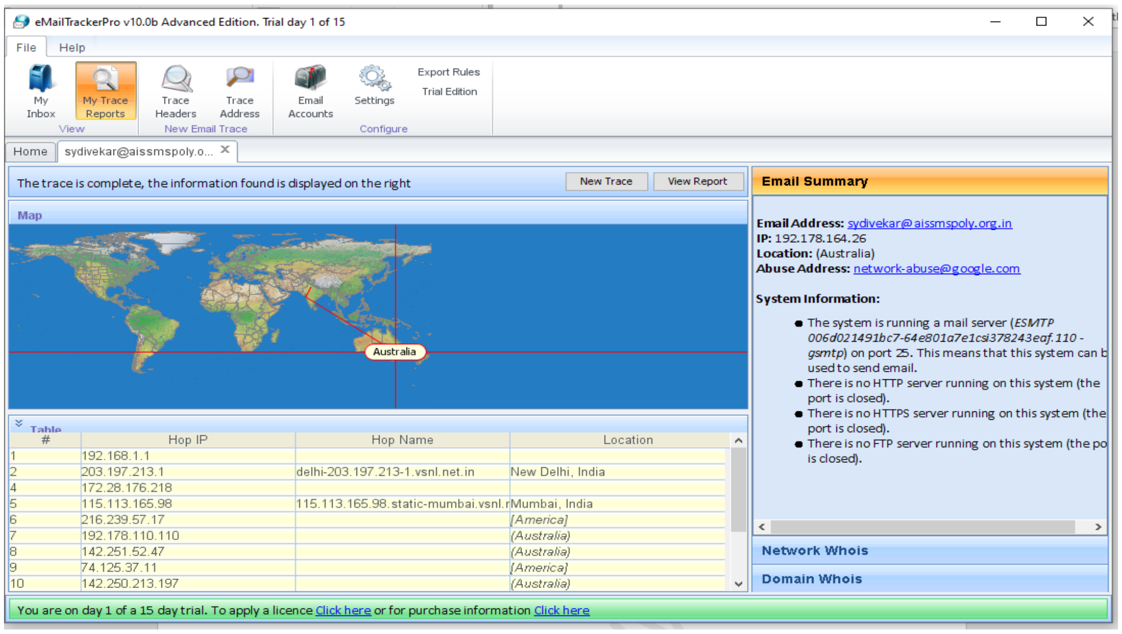
Enter Details

Email address: sydivekar@aissmspoly.org.in

Trace Cancel

Step 3: Click on the **"Trace Email"** button to begin analysis.
The software will process the header and display information such as:

- **Sender's IP address**
- **Originating location**
- **Mail server path**
- **Delivery hops and timestamps**



The trace is complete, the information found is displayed on the right

#	Hop IP	Hop Name	Location
1	192.168.1.1		
2	203.197.213.1	delhi-203.197.213-1.vsnl.net.in	New Delhi, India
4	172.28.176.218		
5	115.113.165.98	115.113.165.98.static-mumbai.vsnl.r	Mumbai, India
6	216.239.57.17		[America]
7	192.178.110.110		(Australia)
8	142.251.52.47		(Australia)
9	74.125.37.11		[America]
10	142.250.213.197		(Australia)

Email Summary

Email Address: sydivekar@aissmspoly.org.in
IP: 192.178.164.26
Location: (Australia)
Abuse Address: network-abuse@google.com

System Information:

- The system is running a mail server (*ESMTP 006d021491bc7-64e801a7e1csi378243eaf.110 - gsmtp*) on port 25. This means that this system can b used to send email.
- There is no HTTP server running on this system (the port is closed).
- There is no HTTPS server running on this system (the port is closed).
- There is no FTP server running on this system (the po is closed).

You are on day 1 of a 15 day trial. To apply a licence Click here or for purchase information Click here

Step 4: Review the analysis results displayed on screen.
You can identify the **geographical source** of the email and detect possible **spoofing or spam** activity.

IX. Precautions

1. Do not trace personal or confidential emails without consent.
2. Use tracing only for **educational or forensic analysis** purposes.
3. Be aware that some emails (especially from large providers) use **relay servers**, making exact tracing difficult.
4. Avoid using third-party websites that store header data without permission.

X. Practical related questions

Note: Below given are few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. What is an email header and why is it important in email security?
2. How can the origin of an email be determined using Email Tracker Pro?
3. Explain the purpose of the “Received” field in an email header.
4. What are some indicators of a phishing or spoofed email?
5. Perform an email trace and identify the IP address and location of the sender.

Space for Answer:

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XI. Exercise

1. Trace at least two sample emails (one genuine and one spam) using Email Tracker Pro.
2. Compare the routing paths and origins of both messages.
3. Research and report one real-world cybercrime case solved through email forensics.

XII. References / Suggestions for further reading

1. Stallings, W. Cryptography and Network Security: Principles and Practice.
2. Kahate, A. Cryptography and Network Security.
3. NPTEL Course: Introduction to Information Security.
4. Email Tracker Pro Official Website: https://www.emailtrackerpro.com
5. Gmail Help: View Original Message and Headers.
6. Virtual Labs (IIIT Hyderabad): https://cse29-iiith.vlabs.ac.in/List%20of%20experiments.html

XIII. Assessment schemes

Performance Indicators		**Weightage**
Process related (15 Marks)		**60 %**
1	Correct extraction of email header information	20 %
2	Successful tracing and interpretation of sender's origin	30 %
3	Quality of output achieved(LLO mapped)	10 %
Product related (10 Marks)		**40 %**
4	Accuracy of trace report (origin, IP, location)	20 %
5	Answer to sample questions	20 %
Total 25 Marks		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process-related Assessment 15 marks	**Product-related Assessment 10 marks**	**Total (25 marks)**	