

## Section 2.2 – Locks and Keys

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### Legal Notice

- Laws regarding lock picking vary significantly state-by-state
- In most states purchase and possession of dedicated lock picking tools is legal
  - Penalties are raised significantly if you get caught using them in the commission of a crime



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## What Is Physical Security?

- Any physical object that creates a barrier to unauthorized access
- This includes: locks, latches, safes, alarms, guards, guard dogs, doors, windows, walls, ceilings, floors, fences, door strikes, door frames and door closers

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## Is Physical Security An IT Concern?

- You have been working hard to secure your network from cyber attacks
  - Redundant layers of antivirus programs, firewalls and intrusion detection systems should protect against every possible electronic method of entry
- But what if an attacker gains access to the server room or network wiring closet ...
- Is you network still safe?

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## Destructive vs. Nondestructive Entry

- Destructive entry
  - Involves using force to defeat physical security
  - Methods involve crowbars, bolt cutters and sledge hammers
  - Negative impact on IT resources is apparent
  - Remediation steps also obvious
- Nondestructive entry
  - Compromises security without leaving signs of a breach
  - Defeats intrusion detection
  - Greater and long-term threat

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## Compromising Locks

- For centuries, the lock has been one of the cornerstones of physical security
  - We rely on dozens of them every day to protect people and assets
- The trust most people place in locks is unwarranted
  - Most locks can be easily compromised with nondestructive methods
  - Sometimes within seconds and with readily available tools
- “Locks keep honest people honest”

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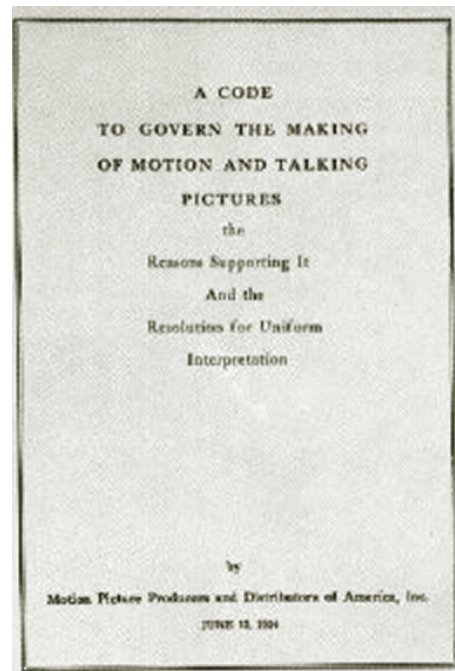
# Lock Picking

- Lock picking had been the exclusive art of locksmiths, professional thieves, spies and magicians for hundreds of years
- However, with the advent of the Internet, information about lock picking methods and tools has become readily available
  - E.g., YouTube has many lock picking videos

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# Lock Picking in Movies

- Genuine lock picking in movies used to be prohibited
- Before 1967, the Hays code (Motion Picture Production Code) required censorship of Hollywood movies
  - “All detailed (that is, imitable) depiction of crime must be removed, such as lock picking or mixing of chemicals to make explosives”



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## LOCK TYPES

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## TSA Lock

- The U.S. government has established a set of rules for the inspection of baggage without the presence of passengers
- Special TSA-approved locks allow both inspection and protection against theft
- An important element is that the inspection must be easily verifiable by the user

Transportation Security Administration

**Baggage Locked?**

Please use a TSA-recognized lock or leave your baggage unlocked to avoid having your lock broken if a physical inspection is required.  
A list of TSA-recognized locks can be found at: [www.TSA.gov](http://www.TSA.gov).  
Baggage may be searched at any time.

**¿Está cerrado su equipaje?**

Por favor use un candado reconocido por TSA o deje su equipaje sin cerrar para evitar que se tenga que romper el candado si se necesita hacer una inspección física.  
Se puede encontrar una lista de candados reconocidos por TSA en: [www.TSA.gov](http://www.TSA.gov).  
El equipaje se puede registrar en cualquier momento.

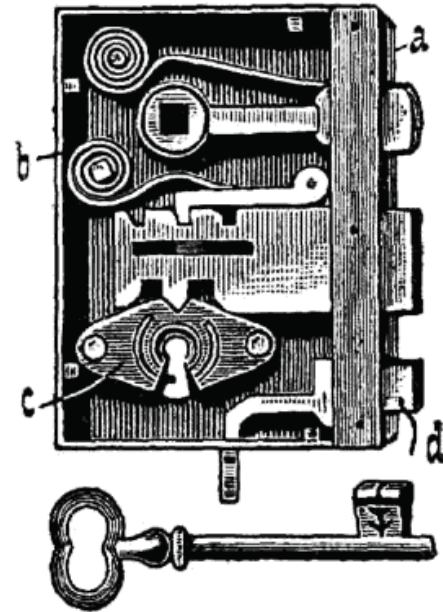
TSA Contact Center 1-866-289-9673 [www.TSA.gov](http://www.TSA.gov)

Public domain government image

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## Warded Locks

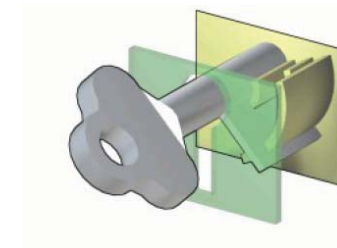
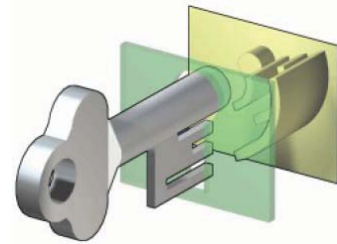
- Locks of this type were used in ancient times
- The key moves the bolt assisted by a support spring
- Security relies on the fact that not all keys pass through the key hole



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## Skeleton Key

- Usually in old style doors or desks
- Different concentric obstructions
- Easy to lock pick with Skeleton keys
- They come from ancient Rome



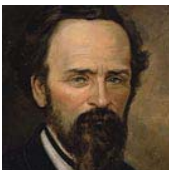
# Pick vs. Bypass

Break open a lock in a nondestructive manner can be achieved either through:

- Pick: acting on the lock mechanism simulating the operation of the key
- Bypass: manipulation of the bolt without using the lock

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## 1860: Yale Pin Tumbler Lock



Public domain image of Linus Yale, Jr.

- Modern version of the Egyptian single-pin design
- Utilizes two pins for locking
- Double-detainer theory of locking
- Created shear line

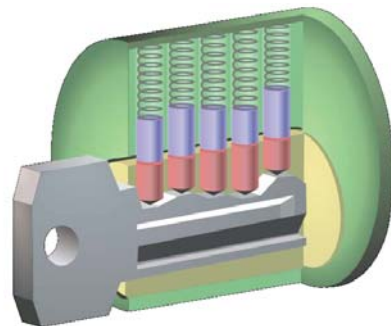
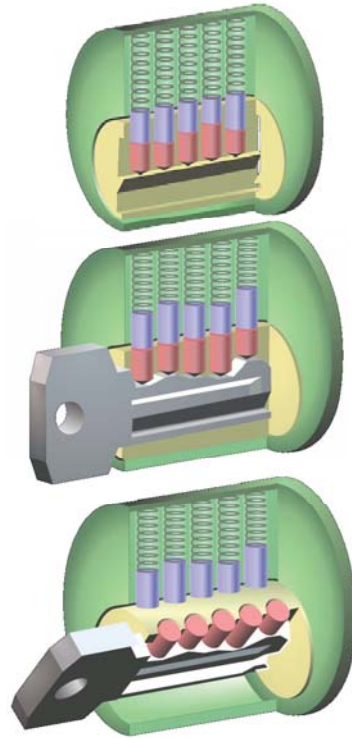


Image from [http://en.wikipedia.org/wiki/File:Pin\\_tumbler\\_with\\_key.svg](http://en.wikipedia.org/wiki/File:Pin_tumbler_with_key.svg) used with permission under Gnu Free Documentation License 1.2

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# How Does a Pin Tumbler Lock Work?

1. When a key is not present, the pin stacks are pushed down by the springs so that the driver (top) pins span the plug and the outer casing, preventing the plug from rotating.
2. When the correct key is inserted, the ridges of the key push up the pin stacks so that the cuts of the pin stacks are aligned with the shear line.
3. The alignment of the cuts with the shear line allows the plug to be rotated.



Images from [http://en.wikipedia.org/wiki/File:Pin\\_tumbler\\_with\\_key.svg](http://en.wikipedia.org/wiki/File:Pin_tumbler_with_key.svg) used with permission under Gnu Free Documentation License 1.2

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# How Does a Pin Tumbler Lock Work?

- If an inappropriate key is inserted, then the pins do not align along the shear line and the lock does not turn.

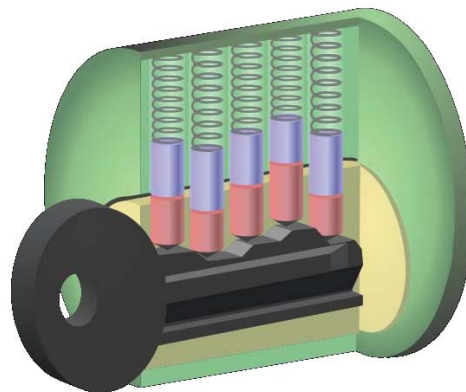


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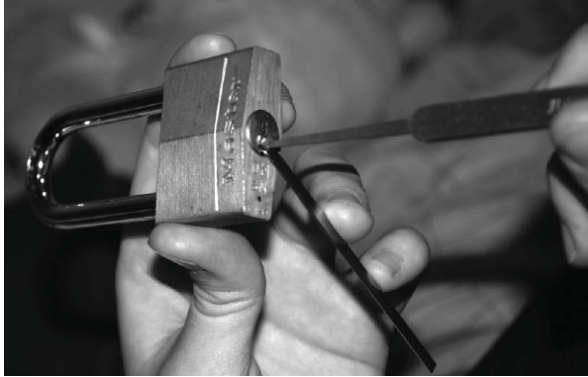


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## LOCK PICKING

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## Terminology

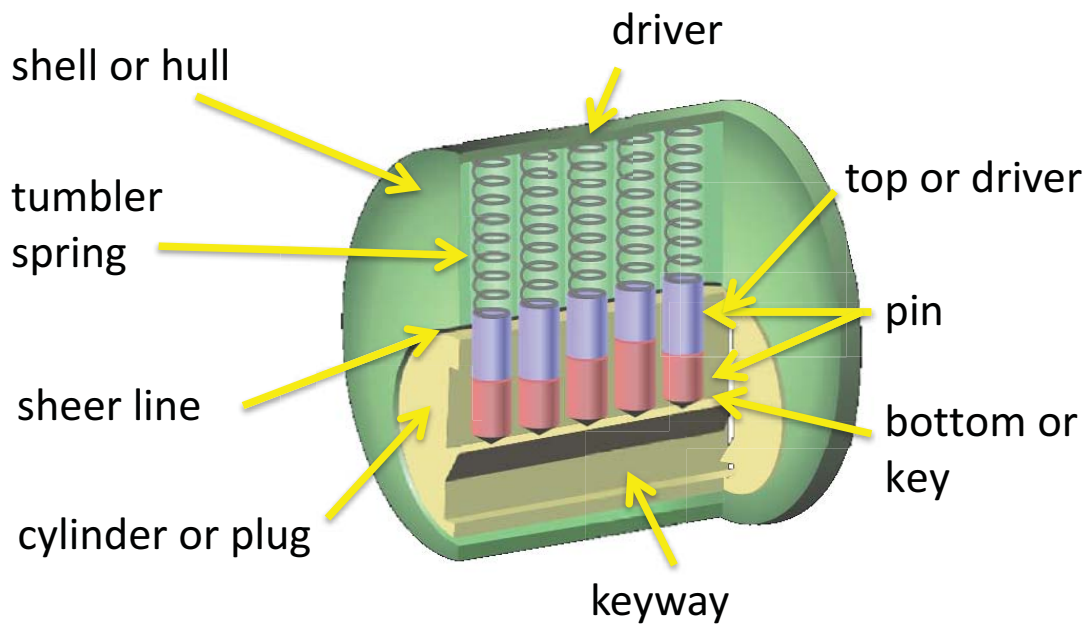


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# Lockpicking Tools

- Feelers
- Scrubbers
- Tension tools



Photo by Jennie Rogers included with permission.

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# Feeler Picking

- Apply light tension
- Lift one pin at a time
  - Identify binding pin
- Lift binding pin until it reaches the shear line
- Setting the binding pin will rotate the lock slightly
- Find next pin and repeat the process

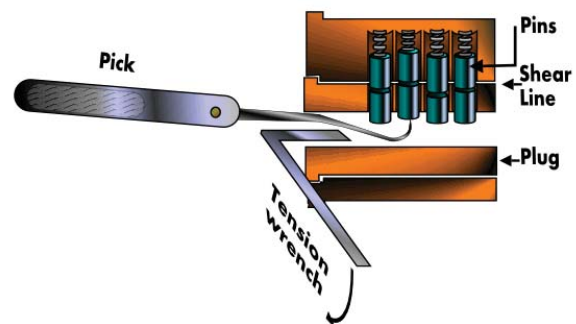


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## Scrubbing / Raking

- Apply light tension
- Work over pins back to front in a circular motion
  - attempting to pop them into the shear line with the combination of tension
- Good for beginners
- Usually employ snake pick or half diamond



Photo by Jennie Rogers included with permission.

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## The Math of Lock Picking

- Suppose we have
  - 40 different kinds of key blanks
  - 7 pin positions
  - 8 different possible pin heights
- Then the total number of possible locks is
  - $40 \times 8^7 = 83,886,080$
- Not all these are possible, however, as it is difficult to put long teeth next to small teeth.

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# Rights Amplification in Master Keyed Systems

Reverse engineer master key from change key

Each lock has  $P$  pins, with  $D$  potential cut heights

Create  $D-1$  test keys for each pin position  $p$

Cut all pin positions except  $p$  as known change key

Published by Matt Blaze at Penn

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## Rights Amplification (continued)

Query the lock until you find each pin position

i.e. To determine first key cut depth insert each of the  $D-1$  test keys and determine which one does not bind to the pin

Repeat for each pin

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# Rights Amplification Statistics

Consumes P(D-1) blanks

Can reduce to P blanks and file down on the fly

But this looks suspicious

Search space is practically pruned by manufacturer specs

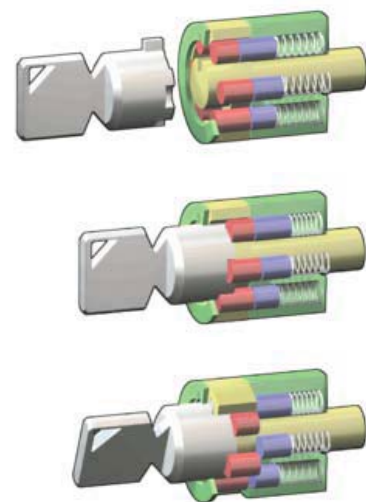
maximum distance limit in legal adjacent cuts

Older installations sometimes require MKs to be higher on the pin stack

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## Tubular lock

- Usually on car alarms or vending machines
- 6-8 pins
- Easy to pick with special tool
- The tool could become a new key



Images from [http://en.wikipedia.org/wiki/File:Tubular\\_locked.png](http://en.wikipedia.org/wiki/File:Tubular_locked.png) used with permission under Gnu Free Documentation License 1.2

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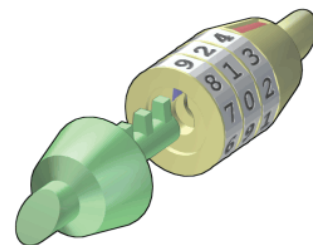
# Statistics

- 4-6 pins, 4-10 levels
- $10^6 = 1,000,000$  possible keys!
- The angular positions of the cylinders allow to obtain about 180 different positions  $(180 \cdot 10)^6 = 3.4012224 \times 10^{19}$
- (Un) fortunately there is a need for some tolerance in locks

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# Combination Locks

- There are locks that do not require a physical key to be opened but a code
- Number of combinations is
  - Number of digits times
  - Length of combination



# Combination Locks

- Inexpensive combination padlocks allow attacks based on reducing the space of possible combinations to try
  - The gears have a higher tolerance of the external disk combination
  - Nominal number of combinations is  $40^3 = 64,000$
  - Possibilities can be reduced to about 80 by detecting critical gear points



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E.g., see <http://www.wikihow.com/Crack-a-%22Master-Lock%22-Combination-Lock>

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# Bumping

- A different way of picking locks
- Virtually all traditional Yale and similar locks can be opened by bumping
- What lock pickers say about bumping:
  - RELIABLE
  - REPEATABLE
  - SIMPLE TO LEARN



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# Bump Keys

- Driver pins “jump” higher than the cylinder just for an instant
- If a light rotational force is applied, the cylinder will turn
- Lock bumping is a very fast method for opening the lock
- The lock is not damaged in any way
- Few key-pin locks cannot be bumped

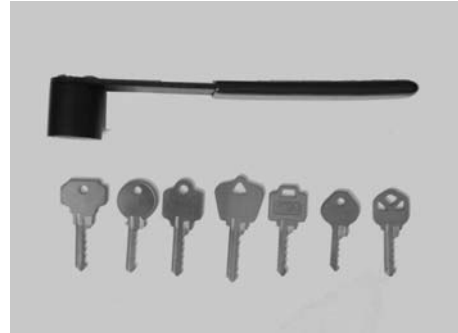


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# Pick Gun

- Manual and electronic pick guns are a popular method for quick and easy ways of opening up doors
- The pick gun is used in a similar way but usually has a **trigger** that creates an upward movement that must be repeated rapidly to open the lock



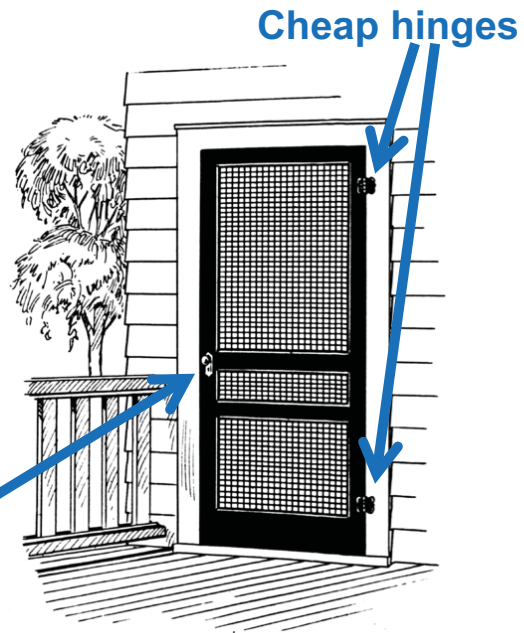
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# Side Channel Attacks

- Rather than attempting to directly bypass security measures, an attacker instead goes around them by exploiting other vulnerabilities not protected by the security mechanisms.
- Side channel attacks are sometimes surprisingly simple to perform.

**High security lock**



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