City Kids

Hardware	
Computational Thinking Binary System CPU Ram (Random Access Memory) Hard Drives Flash memory	Types of Memory and Funneling Display connectors USB (Universal Serial Bus) Wireless (WIFI – Bluetooth) Operating System (OS)

What is Computer Science?	
Knowing how to program is only one element of the field.	معرفة كيفية البرمجة ما هي إلا عنصر واحد من عناصر المجال
Computer science is the study of the theory, design, implementation of any algorithm, and performance of computer software and computer systems, including the study of computing itself.	علوم الكمبيوتر هي دراسة النظرية والتصميم وتنفيذ أي خوارزمية وأداء برامج الكمبيوتر وأنظمة الكمبيوتر، بما في ذلك دراسة الحوسبة نفسها
Their background allows them to determine the best performance possible.	تسمح لهم خلفيتهم بتحديد أفضل أداء ممكن

A Computer System is divided into two categories:
ينقسم نظام الكمبيوتر إلى فئتين

Hardware	Software
The physical component of the computer المكون المادي للكمبيوتر	Software is a set of instructions that tells a computer exactly what to do البرنامج عبارة عن مجموعة من التعليمات التي تخبر الكمبيوتر بما يجب فعله بالضبط
It is manufactured يتم تصنيعه	It is developed and engineered تم تطويره وهندسته
Electronic and other materials are used to create hardware يتم استخدام المواد الإلكترونية وغيرها لإنشاء الأجهزة	Created by utilizing a computer language to write instructions تم إنشاؤها باستخدام لغة الكمبيوتر لكتابة التعليمات
Hardware typically wears out over time عادةً ما تتآكل الأجهزة بمرور الوقت	Software does not wear out with time. However, it may contain flaws and glitches تم إنشاؤها باستخدام لغة الكمبيوتر لكتابة التعليمات
Main categories: الفئات الرئيسية	Mainly divided into: تنقسم بشكل رئيسي إلى
Input devices أجهزة إدخال Output devices أجهزة الخرج Storage devices أجهزة التخزين	System software برنامج النظام Programming software برامج البرمجة Application software تطبيق البرمجيات

Processing devices أجهزة المعالجة	
Computer scientists are problem solvers **علماء الكمبيوتر هم حل المشاكل**	
Computer science is fundamentally problem solving. **علوم الكمبيوتر هي في الأساس حل المشكلات** **A computer scientist's goal is to develop list of instructions for solving any problem that might arise.** **هدف عالم الكمبيوتر هو وضع قائمة من التعليمات لحل أي مشكلة قد تنشأ**	

Four Main Problem Solving Steps: **أربع خطوات رئيسية لحل المشكلات**	
Understand the Problem **فهم المشكلة**	**Design a Solution تصميم الحل** (Formulate an algorithm to solve your problem) قم بصياغة خوارزمية لحل مشكلتك
Implement your solution **قم بتنفيذ الحل الخاص بك**	**Check your solution** **تحقق من الحل الخاص بك**
Computational thinking:	
Computational thinking is thinking algorithmically, taking inputs to a problem and carefully going step by step to produce an output.	**We can then present these solutions in a way that a computer, a human, or both, can understand.**
التفكير الحسابي هو التفكير بطريقة خوارزمية، حيث يأخذ مدخلات للمشكلة ويتحرك بعناية خطوة بخطوة لإنتاج المخرجات	يمكننا بعد ذلك تقديم هذه الحلول بطريقة يمكن للكمبيوتر أو الإنسان أو كليهما فهمها

Pseudocode

Step 1: Add up the items by type or flavor.
Step 2: Assign the price per each item type.
Step 3: Multiply the number of items by type with its cost per unit.
Step 4: Add the total cost for each type together.
Step 5: Bon Appetit!

Pseudocode

Step 1: Add up the items by type or flavor.
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Flowchart

What is Computer Science ?

- To begin doing that, we'll need a way to represent inputs and outputs, so we can store and work with information in a standardized way.

(Binary System)

#2:

1. What is computational thinking?
   A. Giving instructions to a computer
   B. Thinking like a computer - in binary
   C. Using a set of techniques and approaches to help to solve problems
2. Which of the following is an example of thinking computationally?
   A. Planning out your route when going to meet a friend
   B. When going to meet a friend, wandering around until you find them
   C. When going to meet a friend, asking a parent to plan your route for you
3. What is decomposition?
   A. Breaking down a complex problem or system into smaller, more manageable parts
   B. Adding detail to make a problem more complex
   C. When you ignore the unnecessary detail in a problem

Binary System:

Unary System:

Each digit represents a single value of one (Base-1).

Binary System:

Bi- comes from Latin bis, meaning "twice, doubly."
(Base-2).

Binary System:
(Base-2)
0 0 0 1 1

Binary System				Decimal System			
Computer No. System				Human No. System			
Base 2 system (0 , 1)				Base 10 system (0,1,2,3,4,5,6,7,8,9)			
Power of 2				Power of 10			
...	2^2	2^1	2^0	...	10^2	10^1	10^0
...	4	2	1	...	100	10	1
0	1	1	1		2	5	5
7 =	1*4	1*2	1*1	255 =	2*100	5*10	5*1

Binary System:

Example:

How 11111111 in binary system = 255 in decimal system

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
1	1	1	1	1	1	1	1

128	64	32	16	8	4	2	1
1	1	1	1	1	1	1	1
128	64	32	16	8	4	2	1

1	1	1	1	1	1	1	1	
128 +	64 +	32 +	16 +	8 +	4 +	2 +	1	= 255

11111111 = 255

bit digit

11111111 = 255

bit Byte digit

11111111 = 255

bit Byte digit

- 1 TB (Terabyte) = 1,024 GBs (Gigabytes)
- 1 GB (Gigabyte) = 1,024 MBs (Megabytes)
- 1 MB (Megabyte) = 1,024 KBs (kilobytes)
- 1 KB (Kilobyte)= 1,024 Byte (Byte)
- 1 B (Byte) = 8 b (bits)

#3:

01001000 01001001 00100000 00111010 00101001

Representing Letters

ASCII (American Standard Code for Information Interchange):

- Original ASCII is 7 bits, thus giving 128 characters.

#######
0000000
1111111
0111111
1110000
1010101
$2^7 = 128$

########
$2^8 = 256$

####
0000
1234
1024
3240
2568
$10^4 = 10000$

Representing Letters

ASCII : Original ASCII is 7 bits, thus giving 128 characters.

0	NUL	16	DLE	32	SP	48	0	64	@	80	P	96	`	112	p
1	SOH	17	DC1	33	!	49	1	65	A	81	Q	97	a	113	q
2	STX	18	DC2	34	"	50	2	66	B	82	R	98	b	114	r
3	ETX	19	DC3	35	#	51	3	67	C	83	S	99	c	115	s
4	EOT	20	DC4	36	$	52	4	68	D	84	T	100	d	116	t
5	ENQ	21	NAK	37	%	53	5	69	E	85	U	101	e	117	u
6	ACK	22	SYN	38	&	54	6	70	F	86	V	102	f	118	v
7	BEL	23	ETB	39	'	55	7	71	G	87	W	103	g	119	w
8	BS	24	CAN	40	(	56	8	72	H	88	X	104	h	120	x
9	HT	25	EM	41	)	57	9	73	I	89	Y	105	i	121	y
10	LF	26	SUB	42	*	58	:	74	J	90	Z	106	j	122	z
11	VT	27	ESC	43	+	59	;	75	K	91	[	107	k	123	{
12	FF	28	FS	44	,	60	<	76	L	92	\	108	l	124	|
13	CR	29	GS	45	-	61	=	77	M	93	]	109	m	125	}
14	SO	30	RS	46	.	62	>	78	N	94	^	110	n	126	~
15	SI	31	US	47	/	63	?	79	O	95	_	111	o	127	DEL

Representing Letters

ASCII (American Standard Code for Information Interchange):

- Original ASCII is 7 bits, thus giving 128 characters.
- Extended ASCII is 8 bits, yielding 256 characters

ASCII is Limited!!

Dec	Char	Dec	Char	Dec	Char	Dec	Char
128	Ç	160	á	192	└	224	α
129	ü	161	í	193	┴	225	ß
130	é	162	ó	194	┬	226	Γ
131	â	163	ú	195	├	227	π
132	ä	164	ñ	196	─	228	Σ
133	à	165	Ñ	197	┼	229	σ
134	å	166	ª	198	╞	230	µ
135	ç	167	º	199	╟	231	τ
136	ê	168	¿	200	╚	232	Φ
137	ë	169	⌐	201	╔	233	Θ
138	è	170	¬	202	╩	234	Ω
139	ï	171	½	203	╦	235	δ
140	î	172	¼	204	╠	236	∞
141	ì	173	¡	205	═	237	∅
142	Ä	174	«	206	╬	238	ε
143	Å	175	»	207	╧	239	∩
144	É	176	░	208	╨	240	≡
145	æ	177	▒	209	╤	241	±
146	Æ	178	▓	210	╥	242	≥
147	ô	179	│	211	╙	243	≤
148	ö	180	┤	212	╘	244	⌠
149	ò	181	╡	213	╒	245	⌡
150	û	182	╢	214	╓	246	÷
151	ù	183	╖	215	╫	247	≈
152	ÿ	184	╕	216	╪	248	°
153	Ö	185	╣	217	┘	249	∙
154	Ü	186	║	218	┌	250	·
155	¢	187	╗	219	█	251	√
156	£	188	╝	220	▄	252	ⁿ
157	¥	189	╜	221	▌	253	²
158	₧	190	╛	222	▐	254	■
159	ƒ	191	┐	223	▀	255	□

UNICODE:

- Is a modern standard for text representation that defines each of the letters and symbols commonly used in today's digital and print media.
- Is a bigger set of characters that includes written languages other than English and even emoji!

UTF-8	Requires 8, 16, 24 or 32 bits (one to four bytes).
Utf-16	Requires either 16 or 32 bits to encode a character.
UTF-32	Always requires 32 bits to encode a character.

```
<html lang="en">
    <head>
        <meta charset="utf-8" />
```

$2^{16} = 65536$ 2^{32}

- All are still represented by a pattern of bits.

What is Computer Science ?

- To begin doing that, we'll need a way to represent inputs and outputs, so we can store and work with information in a standardized way.

What is Computer Science ?

#4:

01001000 01001001 00100000 00111010 00101001

Hardware

Main categories:

1. Processing devices
2. Storage devices
3. Input devices
4. Output devices

Hardware

Motherboard:

- Is the backbone that ties the computer's components together and allows them to talk to each other.
- Without it, none of the computer pieces could interact.

- In 1981, the first motherboard was used in the IBM computer that was originally known as planar.

#5:

1. Processing Devices:

Are the components responsible for the processing of information within the computer system. This includes devices such as:

- CPU
- GPU
- Video Card
- Sound Card

1. Processing Devices:

CPU (Central Processing Unit) (Processor)

1. Processing Devices:

CPU (Central Processing Unit) (Processor)

Hardware

1. Processing Devices:

   The CPU is the brain of the computer:
   - Does all the thinking

The term "computer" is derived from the Latin word "computare" which means to calculate.

Binary System:

1 1 0 1 1 Binary System

N° 24,850 A.D. 1904

Date of Application, 16th Nov., 1904
Complete Specification Left, 15th Aug., 1905—Accepted, 21st Sept., 1905

PROVISIONAL SPECIFICATION.

Improvements in Instruments for Detecting and Measuring Alternating Electric Currents.

I JOHN AMBROSE FLEMING of University College, Gower Street, in the County of London, Doctor of Science, do hereby declare the nature of this invention to be as follows:—

It is well known that alternating electric currents can only be detected and measured by the use of some instrument, the indications of which do not depend upon the direction of the current. Hence an instrument of which the indication is dependent upon the heating of a wire by the current commonly known as a hot wire instrument is suitable for the above purpose. Also one depending upon the attraction or repulsion of electric current, commonly known as an electro-dynamometer, because in both these cases the indication or reading of the instrument is the same even if the current direction is reversed.

On the other hand, an ordinary galvanometer of the movable needle or movable coil type cannot by itself be used for detecting or measuring alternating currents because it only gives an indication with a unidirectional current and is therefore unaffected by an alternating current.

The object of my invention is to provide a means by which an ordinary galvanometer can be used to detect and measure alternating electric currents and especially high frequency alternating currents commonly known as electric oscillations.

The means I employ for this purpose consists in the insertion in the circuit of the alternating current of an appliance which permits only the passage of electric current in one direction and constitutes therefore an electrical valve.

I construct it as follows:—

In a glass bulb, I seal two or more carbon filaments such as are used for the

Instruments for Detecting and Measuring Alternating Electric Currents.

These bulbs have the property that inside the bulb, negative electricity can move from the hot to the cold carbon filament even under a very low electromotive force but it cannot move in the opposite direction. Hence, owing to the arrangement of the bulbs, the alternating current arriving at the common terminal splits and all the positive alternations pass through one bulb and all the negative through the other bulb. The galvanometer is therefore affected solely by currents flowing in one direction. The bulbs serve the purpose of separating out the two constituents of the alternating current.

In place of two bulbs, one only may be used in series with a galvanometer and then the bulb only allows currents to pass in one direction and the galvanometer gives an indication.

The device is especially applicable to the detection and measurement by an ordinary galvanometer of high frequency electric currents or oscillations, where any form of mechanical or electrolytic rectifier is useless.

I construct the bulbs with two or more sets of carbon filaments.

One set when rendered incandescent forming one electrode of the valve and the other set kept cold, the other electrode.

In place of carbon filament for the cold electrodes I use sometimes, loops of platinum wire or platinum wires with plates on the end.

In making the connections of the bulb to the alternating current circuit it is essential to join one end of the galvanometer wire to that terminal of the hot carbon filament to which the negative end of the local or heating battery is applied.

The other end of the galvanometer and the two ends or all the ends of the cold filaments taken together constitute the terminal of the indicating appliance.

The carbon filament may also be heated by part of the alternating current which is being rectified or measured.

Any other method of heating one or more of the carbon filaments may be employed.

The above described multiple carbon filament bulb and a galvanometer may be used as a receiving instrument in wireless telegraphy.

For this case, the aerial receiving wire has the primary circuit of an oscillation transformer inserted in it and one of the above described electrical valves and a galvanometer are inserted in the secondary circuit.

The feeble alternating currents excited in the aerial by electric waves, then make themselves evident by indications in the galvanometer.

Dated this 16th day of November 1904.

J. A. FLEMING.

Thomas Edison

John Ambrose Fleming

Lee de Forest

1904

Vacuum tube

Vacuum tube

Lee de Forest

Vacuum tube

1945

1947

الترانزستور

في عام 1974 ظهرت مقاومة النقل) بالإنجليزية(Transfer Resistor : التي أصبحت تعرف اختصاراً باسم الترانزستور) بالإنجليزية(Transistor : وتم اختراعها في معامل بل على يد ثلاثة من العلماء هم جون باردين ووالتر براتين وويليام شوكلي، وقد حصلوا على جائزة نوبل في الفيزياء عام 1956 بسبب هذا الاختراع.[1] والترانزستور عبارة عن دائرة إليكترونية صغيرة الحجم تماثل أقل من رأس الدبوس وتستطيع القيام بالمهام والوظائف التي كان يقوم بها الصمام المفرغ الذي يصل حجمه إلى حجم الإبهام على الأقل، ومن هنا أمكن استخدامه في الحاسب ليقل حجمه إلى حد كبير ومن هنا بدأ أيضاً تطوير الترانزستور ليقل حجمه وتزيد كفاءته بعد ذلك.

1959 mo atalah

Hardware

CPU (Central Processing Unit) (Processor)

Hardware

CPU (Central Processing Unit) (Processor)

ALU (Arithmetic & Logic Unit):

- Arithmetic functions include addition, subtraction, multiplication ,and division.
- Logical functions mainly include selecting, comparing, and merging the data.

قانون مور Moore’s Law

بعد ذلك ، في عام 1965 ، أدلى رجل يُدعى جوردون مور بملاحظة والتي كان من شأنها بعد ذلك أن تصبح شيئًا من نبوءة أو توقع تحقق ذاتها . حيث أشار إلى أنه في غضون فترة زمنية معينة – اعتمادًا على من تسأل ومتى تسأل ، والتي تتراوح في فترة بين 18 و 24 شهرًا – ستسمح التحسينات في عمليات التصنيع التكنولوجية لعدد المكونات المنفصلة على بوصة مربعة (6.5 سنتيمترات مربعة) من رقائق السيليكون بالمضاعفة (أي أن عدد المكونات على كل شريحة سيليكون سيتضاعف كل فترة كالمذكورة في الأعلى) .

رأى أن الشركات التي صممت الرقائق سوف تجد طرقًا جديدة لإنشاء مكونات أصغر ثم تحسين عملية التصنيع بحيث يكون من المنطقي أكثر من الناحية المالية بناء شرائح أكثر قوة

Hardware

CPU (Central Processing Unit) (Processor)

Control Unit:

- It interacts with both the main memory and arithmetic logic unit.
- it issues control signals that control hardware
- it moves data around the system

.

Hardware

CPU (Central Processing Unit) (Processor)

Control Unit:

- It interacts with both the main memory and arithmetic logic unit.
- it issues control signals that control hardware
- it moves data around the system
- it fetches, decodes and executes instructions.

Hardware

Fetch-Decode-Execute Cycle

How the CPU can perform calculations, using a process known as the fetch-decode-execute cycle.

Hardware

CPU (Central Processing Unit) (Processor)

Registers:

Are small amounts of high-speed memory contained within the CPU. They are used by the processor to store small amounts of data that are needed during processing, such as:

- the address of the next instruction to be executed.
- the current instruction being decoded.
- the results of calculations.

- 1 TB (Terabyte) = 1,024 GBs (Gigabytes)
- 1 GB (Gigabyte) = 1,024 MBs (Megabytes)
- 1 MB (Megabyte) = 1,024 KBs (kilobytes)
- 1 KB (Kilobyte)= 1,024 Byte (Byte)
- 1 B (Byte) = 8 b (bits)

Registers:

Commonly used types of registers

- AC (Accumulator)
- AR (Address Register)
- DR (Data Register)
- IR (Index Registers)
- PC (Program Counter)
- MDR (Memory Data Register)
- MBR (Memory Buffer Register) and more.

#7:

Search for types of register

Hardware

CPU (Central Processing Unit) (Processor)

Cashe Memory

Hardware

CPU (Central Processing Unit) (Processor)

Cashe Memory

Register faster than L1, L1 faster than L2, L2 faster than L3.

Register is visible by compiler in software, computer can see register and store in register.

L1, L2, L3 are not visible for computer or software, only visible for CPU.

CPU start search in L1 (level 1) if not found the data goes to L2 if not found the data goes to L3 if not found the data goes to RAM.

Hardware

1. Processing Devices:

The CPU is the brain of the computer:

- Does all the thinking
- Performs math in numbers fed to it
- Helps display numbers on a screen
- Adds or deletes numbers
- Cores and Multithreading

#8:

1. What is the purpose of the CPU?
   A. To process all the data and instructions.
   B. To turn the computer on.
   C. To create PowerPoint presentations.
   D. To provide power to the computer.

2. What is the job of the control unit?
   A. It carries out calculations
   B. It stores information.
   C. It does nothing.
   D. It controls the input and output of data to make sure that it gets to the right place.

3. Which level of cache is the fastest but has the smallest capacity?
   A. Level 1
   B. Level 2
   C. Level 3

#8:

4. What are registers used for?
   A. To check that students are in school.
   B. To temporarily hold bits of data needed by the CPU.
   C. To make sure that the CPU runs properly.
   D. To make the CPU faster.

5. What does CPU stand for?
   A. Control Processing Unit
   B. Central Processing Unit
   C. Central Power Unit
   D. Center Power Unit

6. Which transfer is faster
   A. data between the cache and the CPU
   B. data between the RAM and cache
   C. data between the RAM and CPU
   D. data between the hard drive and CPU

#8:

7. CPU Cache is located on
   A. The CPU
   B. The RAM
   C. The hard drive
   D. The motherboard

8. Which part of the Fetch-Decode-Execute cycle gets the instruction from the RAM?
   A. Fetch
   B. Decode
   C. Execute

9. Cache memory acts as a buffer between the processor and To start up the computer
   A. the RAM
   B. the hard drive
   C. the motherboard
   D. the user

Boot cast

128	64	32	16	8	4	2	1
0	1	0	0	1	0	0	0
0	64	0	0	8	0	0	0
72							

128	64	32	16	8	4	2	1
0	1	0	0	1	0	0	1
0	64	0	0	8	0	0	1
73							

128	64	32	16	8	4	2	1
0	0	1	0	0	0	0	0
0	0	32	0	0	0	0	0
32							

128	64	32	16	8	4	2	1

0	0	1	1	1	0	1	0
0	0	32	16	8	0	2	0
58							

128	64	32	16	8	4	2	1
0	0	1	0	1	0	0	1
0	0	32	0	8	0	0	1
41							

Hardware

CPU (Central Processing Unit)

Cores:

- 1 core
- 2 cores(Dual-core)
- 4 cores(Quad-core):
  - Allow you to render video (slowly) or play games (at lower resolutions) in addition to all your regular work or school tasks.
  - Most gamers will be fine here as long as you are not playing the most processor-intensive games and you have a dedicated GPU.
- 6 cores(hexa-core)
- 8 cores(Octa-core)

Cores:

- 1 core
- 2 cores(Dual-core)
- 4 cores(Quad-core)
- 6 cores(hexa-core)
- 8 cores(Octa-core):
  - if you're a pro gamer , a video editor, or an engineer.
  - Video gamers who play, record, and stream intensive games should opt for more cores for as much power as possible.
  - And if you routinely use power-intensive software like VR or AutoCAD, this is your sweet spot.

Hardware

CPU (Central Processing Unit)

Cores

Hyper-Threading

Task Manager
File Options View
Processes Performance App history Startup Users Details Services
CPU
15% 3.39 GHz
Memory
5.3/7.9 GB (67%)
Disk 0 (C: E:)
HDD
0%
Wi-Fi
Wi-Fi 3
S: 0 R: 0 Kbps
GPU 0
Intel(R) HD Graphics ...
11%
GPU 1
AMD FirePro W4170...
0%
CPU
Intel(R) Core(TM) i7-4810MQ CPU @ 2.80GHz
% Utilization
100%
60 seconds
0
Utilization
15%
Speed
3.39 GHz
Processes
205
Threads
2478
Handles
87410
Up time
0:13:08:01
Base speed: 2.80 GHz
Sockets: 1
Cores: 4
Logical processors: 8
Virtualization: Enabled
L1 cache: 256 KB
L2 cache: 1.0 MB
L3 cache: 6.0 MB

Hardware

Main Categories:

1. Processing devices (CPU).
2. Storage devices
3. Input devices
4. Output devices

Hardware

RAM (Random Access Memory)

Hardware

CPU (Central Processing Unit) (Processor)

Hardware

CPU (Central Processing Unit) (Processor)

Hardware

RAM (Random Access Memory)

RAM: Circuit board with chips that slides into a slot on the motherboard

- Volatile Memory only stores data when the power is on
- The chips store data
- Files and programs are loaded onto these chips when ran
- Fast memory

Hardware

RAM (Random Access Memory)

RAM: Circuit board with chips that slides into a slot on the motherboard

Hardware

RAM (Random Access Memory)

RAM: Circuit board with chips that slides into a slot on the motherboard

Hardware

RAM (Random Access Memory)

RAM: Circuit board with chips that slides into a slot on the motherboard

Capacity: 4 GB
16 GB
32 GB

1 GB = 8,589,934,592 bits

Byte = 8 b (bits)
Kilobyte = 1,024 Byte (Byte)
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Hardware

Memory Hierarchy

Hardware

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Hardware

Binary

We use computers everyday	
Inside a computer are “0s and 1s”	Computers use the binary number system to represent info
How do computers represent info with just binary?	

[MUSIC PLAYING] DAVID J. MALAN:
Odds are, you use a computer most every day. But what's going on inside of that laptop or that desktop. Well, inside of a computer are all these 0s and 1s. And you may have heard, indeed, that computers only understand 0s and 1s, or the, so-called, binary system. But if computers today can do so much, how can they do so much if they can only speak 0s and 1s and not even the entire alphabet that we humans have. Well, consider this. Back in our human world, you might recognize a pattern of symbols like this as the number 123. But why is that? After all, all I did was draw three shapes, really, three glyphs, or three symbols or digits on the screen. But each of these digits has some predefined meaning. If, in fact, if you went to grade school like I did and you learned numbers in this way, odds are, you might recall, that this rightmost column is the so-called one's column or one's place. Then this is the ten's place. And then this is the

hundred's place. Now why is that significant? Well, the reason that 1, 2, 3-- that pattern represents the number we humans know is 123 is that there's a bit of arithmetic going on here. This, after all, means that you should do 100 times 1 plus 10 times 2 plus 1 times 3. That, of course, gives us 100 plus 20 plus 3 or 123. In other words, there's a pattern to these digits, and there's a meaning behind each of their places. Well, it turns out that computers only, indeed, understand 0s and 1s. They can't count as high as 2 and 3 and 4 in the same way we humans can. But they use those 0s and 1s in exactly the same way.

الاحتمالات هي أنك تستخدم الكمبيوتر في أغلب الأحيان كل يوم.

لكن ما يحدث داخل هذا الكمبيوتر المحمول أو سطح المكتب هذا. حسنًا ، يوجد بداخل الكمبيوتر كل هذه 0 و 1. وربما تكون قد سمعت ، بالفعل ، أن أجهزة الكمبيوتر لا تفهم سوى الأصفار والآحاد ، أو ما يسمى بالنظام الثنائي. ولكن إذا كانت أجهزة الكمبيوتر اليوم تستطيع فعل الكثير ، فكيف يمكنها فعل الكثير إذا كانت تتحدث فقط 0 و 1 ولا حتى الأبجدية الكاملة التي لدينا نحن البشر. حسنًا ، اعتبر هذا. بالعودة إلى عالمنا البشري ، قد تتعرف على نمط من الرموز مثل هذا على أنه الرقم 123. لكن لماذا هذا؟ بعد كل شيء ، كل ما فعلته هو رسم ثلاثة أشكال ، في الواقع ، ثلاثة أشكال رمزية ، أو ثلاثة رموز أو أرقام على الشاشة. لكن لكل من هذه الأرقام معنى محدد مسبقًا. إذا ، في الواقع ، إذا ذهبت إلى المدرسة الابتدائية كما فعلت وتعلمت الأرقام بهذه الطريقة ، فمن المحتمل أن تتذكر أن هذا العمود الموجود في أقصى اليمين هو ما يسمى بعمود الشخص أو مكانه. ثم هذا هو مكان العشرة. ثم هذا هو خانة المئات. الآن لماذا هذا مهم؟ حسنًا ، السبب في أن 1 ، 2 ، 3 - يمثل هذا النمط الرقم الذي نعرفه نحن البشر وهو 123 هو أن هناك القليل من العمليات الحسابية تحدث هنا. هذا ، بعد كل شيء ، يعني أنه يجب أن تضرب 100 في 1 زائد 10 في 2 زائد 1 في 3. وهذا ، بالطبع ، يعطينا 100 زائد 20 زائد 3 أو 123. بعبارة أخرى ، هناك نمط لهذه الأرقام ، وهناك معنى وراء كل مكان من أماكنهم. حسنًا ، اتضح أن أجهزة الكمبيوتر فقط ، بالفعل ، تفهم 0 و 1. لا يمكن أن يصل عددهم إلى 2 و 3 و 4 بنفس

الطريقة التي نعد بها نحن البشر. لكنهم يستخدمون تلك 0 و 1 بنفس الطريقة تمامًا.

In fact, consider this. If we consider this pattern 0, 0, 0, to be inside of a computer, and that's what the computer is thinking, well, what number might this be. Well, the spoiler is that this is actually going to represent just 0, thankfully, just like in our human world. But why is that the case? And how can we count higher than 0? Well, in the computer world, realize that these places are just a little different. This is still the one's place, but this next one is not the ten's place anymore. It's, instead, the two's place. And this next place is not the hundred's place anymore. It's, instead, the four's place. And if you think about this, there's still a pattern.

في الواقع ،

اعتبر هذا. إذا اعتبرنا هذا النمط 0 ، 0 ، 0 داخل جهاز كمبيوتر ، وهذا ما يفكر فيه الكمبيوتر ، حسنًا ، ما هو الرقم الذي قد يكون هذا. حسنًا ، المفسد هو أن هذا في الواقع سيمثل 0 فقط ، لحسن الحظ ، تمامًا كما هو الحال في عالمنا البشري. لكن لماذا هذا هو الحال؟ وكيف يمكننا العد أعلى من 0؟ حسنًا ، في عالم الكمبيوتر ، أدرك أن هذه الأماكن مختلفة قليلاً. لا يزال هذا هو مكان الشخص ، لكن هذا المكان التالي لم يعد مكان العشرة بعد الآن. إنه ، بدلاً من ذلك ، مكان الاثنين. وهذا المكان التالي ليس مكان المائة بعد الآن. إنه ، بدلاً من ذلك ، خانة الأربعة. وإذا فكرت في هذا ، فلا يزال هناك نمط.

Previously, it was 1, 10, 100, and then if we kept going, 1,000, 10,000 100,000, and so forth. And here, too, there's a pattern. 1, 2, 4-- and if I kept going-- 8, 16, and 32. And so, in our human world, we tend to use powers of 10. 10 to 0 is 1, 10 to the 1 is 10, 10 to the 2 is 100. And in the computer world, this is 2 to the 0, which is 1, 2 to 1, which is 2, 2 to the 2, or 2 squared, which is 4. 2 to 3 would be 8 and so forth. So all we're doing is changing the base that we're using, so to speak. Instead of powers of 10, we're using powers of 2. And so why is this number 0, 0, 0 the number we humans know as 0 itself? Well, again, if we just do the math, 4 times 0 plus 2 times 0 plus 1 times 0 is, of course, 0 plus 0 plus 0 or the number we humans know as just 0. Well, what if we do another number altogether? Suppose we do this pattern 0, 0, 1. Well, what number does this represent? Well, if you consider the same columns-- 1, 2, and 4--

this means we have four times 0, which is 0, 2 times 0, which is 0, 1 times 1, which is 1.

في السابق ،

كان الرقم 1 ، 10 ، 100 ، ثم إذا واصلنا التقدم ، سيكون 1000 ، 10000 100000 وهكذا دواليك. وهنا أيضًا ، هناك نمط. 1 ، 2 ، 4 - وإذا واصلت - 8 ، 16 ، 32. وهكذا ، في عالمنا البشري ، نميل إلى استخدام قوى 10. 10 إلى 0 هي 1 ، 10 إلى 1 هي 10 ، 10 إلى 2 تساوي 100. وفي عالم الكمبيوتر ، هذا هو 2 أس 0 ، وهو 1 ، 2 إلى 1 ، أي 2 ، 2 إلى 2 ، أو 2 تربيع ، أي 4. 2 إلى 3 سيكون 8 وما إلى ذلك. لذلك كل ما نفعله هو تغيير القاعدة التي نستخدمها ، إذا جاز التعبير. بدلاً من قوى 10 ، نستخدم قوى 2. فلماذا هذا الرقم 0 ، 0 ، 0 هو الرقم الذي نعرفه نحن البشر على أنه 0 نفسه؟ حسنًا ، مرة أخرى ، إذا أجرينا العمليات الحسابية فقط ، 4 في 0 زائد 2 في 0 زائد 1 في 0 هو ، بالطبع ، 0 زائد 0 زائد 0 أو الرقم الذي نعرفه نحن البشر على أنه 0 فقط. حسنًا ، ماذا لو فعلنا عددًا آخر كليا؟ افترض أننا قمنا بهذا النمط 0 ، 0 ، 1. حسنًا ، ما هو الرقم الذي يمثله هذا؟ حسنًا ، إذا نظرت إلى نفس الأعمدة - 1 و 2 و 4 - فهذا يعني أن لدينا أربعة ضرب 0 ، وهو 0 ، 2 في 0 ، وهو 0 ، 1 في 1 ، وهو 1.

So this is the number we humans know as 1. All right. So not all that interesting yet, but what about the number 2? How, in binary, bi meaning two, and the 2 being a 0 and a 1, how, in binary, can I now count as high as 2? Well, if this is my one's place, this is my two's place, and this is my four's place, what digits do I want to put below those places if the only digits I have at my disposal now are not 0 through 9, but just 0 through 1? Well, I don't need a 4, so I can make that a 0. I do need 2 if I want to count to the number we know as two, so I'm going to put a 1 there. And I don't need an extra 1 because an extra 1 would give me 3. So I'm going to do this.

إذن هذا هو الرقم الذي نعرفه نحن البشر بالرقم 1. حسنًا.

إذن ليس كل هذا مثيرًا للاهتمام حتى الآن ، ولكن ماذا عن الرقم 2؟ كيف ، في النظام الثنائي ، ثنائي المعنى اثنان ، والعدد 2 هو 0 و 1 ،

كيف ، في النظام الثنائي ، يمكنني الآن أن أحسب ارتفاعًا يصل إلى 2؟ حسنًا ، إذا كان هذا هو مكاني ، فهذا هو مكاني ، وهذا هو مكاني الأربعة ، ما هي الأرقام التي أريد وضعها أسفل تلك الأماكن إذا كانت الأرقام الوحيدة التي لدي الآن ليست من 0 إلى 9 ، ولكن فقط من 0 إلى 1؟ حسنًا ، لست بحاجة إلى 4 ، لذا يمكنني أن أجعل ذلك 0. أحتاج إلى 2 إذا أردت العد إلى الرقم الذي نعرفه على أنه اثنين ، لذا سأضع 1 هناك. ولست بحاجة إلى 1 إضافي لأن الرقم الإضافي سيعطيني 3. لذا سأفعل هذا.

And so a computer, to store the number we humans know as two in decimal which store it in binary as 0, 1, 0. Because that's 4 times 0 plus 2 times 1 plus time 1 times 0, which, of course, is going to give me the number 2. What about 3? Well, in the world of computers, if we again have our one's place two's place and four's place, how do I now arrange my zeros and ones to give me the number we know as 3? Well, let's see I don't need a 4. That would be too big. I do need a 2, and I do need a 1. And that is now going to give me 3. Because 2 times 1, 1 times 1 is 2, 1 times 1 is 1, 2 plus 1 is 3. Now what about 4? How do I count as high as four? Well, it's even easier, perhaps because we just need a single 1 in this case. We just need 1, 0, 0. Because now I have one 1 in the four's place. And now let's skip ahead. Suppose I want to count up as high as, let's say, 7? What do I do? Well, 7, let me take a byte out of that. So this gives me 4. Let me take a two, that gives me 4 plus 2, that's 6. Let me give myself another 1. 1, 1, 1, in binary, equals 7. Now what about a number like 8? I can't seem to count as high as 8 unless I give myself another bit. But that's OK because, just as in the human world, if you have not a three-digit number, but a four-digit number, you simply add another place. So it might be the ones column, the tens, the hundreds, the thousands. In this case, though, it's going to be the ones, the twos, the fours, and the eights. And so if we want to count as high as 8 in binary, we might do 1, 0, 0, 0, which, of course, gives me 8 times 1. And then everything else is 0. So that gives me the number 8. So even though computers only speak 0s and 1s and only understand the so-called binary system, they can still count as high as we humans can. And they fundamentally do it, really, in the same way.

وهكذا ،

فإن الكمبيوتر ، لتخزين الرقم الذي نعرفه نحن البشر على أنه رقم اثنين في النظام العشري والذي يخزنه في صورة ثنائية مثل 0 ، 1 ، 0.

لأن هذا هو 4 في 0 زائد 2 في 1 بالإضافة إلى الوقت 1 في 0 ، والذي ، بالطبع ، سيحدث لتعطيني الرقم 2. ماذا عن 3؟ حسنًا ، في عالم أجهزة الكمبيوتر ، إذا كان لدينا مرة أخرى منزلة واحد ، خانة اثنين وخانة أربعة ، كيف يمكنني الآن ترتيب الأصفار والآحاد لإعطائي الرقم الذي نعرفه بالرقم 3؟ حسنًا ، دعنا نرى أنني لست بحاجة إلى 4. سيكون ذلك كبيرًا جدًا. أحتاج إلى 2 ، وأحتاج إلى 1. وهذا سيعطيني الآن 3. لأن 2 ضرب 1 ، 1 في 1 يساوي 2 ، 1 في 1 يساوي 1 ، 2 زائد 1 هو 3. والآن ماذا عن 4 ؟ كيف أحسب حتى أربعة؟ حسنًا ، الأمر أسهل ، ربما لأننا نحتاج فقط إلى 1 واحد في هذه الحالة. نحتاج فقط إلى 1 ، 0 ، 0. لأنه الآن لدي واحد في خانة الأربعة. والآن لننتقل إلى الأمام. افترض أنني أريد أن أحسب ارتفاعًا ، دعنا نقول ، 7؟ ماذا أفعل؟ حسنًا ، 7 ، دعني أخرج بايتًا من ذلك. هذا يعطيني 4. اسمحوا لي أن آخذ اثنين ، وهذا يعطيني 4 زائد 2 ، أي 6. اسمحوا لي أن أعطي نفسي أخرى 1. 1 ، 1 ، 1 ، في ثنائي ، يساوي 7. والآن ماذا عن رقم مثل 8؟ لا أستطيع أن أحسب حتى 8 إلا إذا أعطيت نفسي قليلاً. لكن هذا جيد لأنه ، تمامًا كما هو الحال في عالم البشر ، إذا لم يكن لديك رقم مكون من ثلاثة أرقام ، ولكن عددًا مكونًا من أربعة أرقام ، فأنت ببساطة تضيف مكانًا آخر. لذلك قد يكون عمود الآحاد ، العشرات ، المئات ، الآلاف. في هذه الحالة ، على الرغم من ذلك ، ستكون الآحاد والثنائية والأربعة والثمانية. وبالتالي ، إذا أردنا أن نحسب ارتفاعًا يصل إلى 8 في النظام الثنائي ، فيمكننا أن نحسب 1 ، 0 ، 0 ، 0 ، وهو ما يعطيني بالطبع 8 ضرب 1. ثم كل شيء آخر هو 0. وهذا يعطيني الرقم 8 لذلك على الرغم من أن أجهزة الكمبيوتر تتحدث فقط عن الصفر والواحد وتفهم فقط ما يسمى بالنظام الثنائي ، إلا أنه لا يزال بإمكانها الاعتماد على أعلى مستوى ممكن نحن البشر. وهم يقومون بذلك بشكل أساسي ، حقًا ، بنفس الطريقة.

It's just that they have a smaller vocabulary. But why do they have a smaller vocabulary, especially when they can do so much?

Well, it turns out that, in the physical world, it's just convenient to be able to represent only two states instead of 10. And by states, I mean digits, in this case. It's a lot easier in the human world, not to represent 10 possible values 0 or 9, but just two-- 0 and 1. And we could have called those digits anything we wanted, but we humans just standardized our numbers like that. But 0 and 1 is nice because if you think of one of these binary digits or bits as just being a light bulb-- it's either off or on. You can think of a 0 as a light bulb being off and a one as being a light bulb being on. And light bulbs, of course, in our human world just need electricity to run.

كل ما في الأمر أن لديهم مفردات أصغر.

لكن لماذا لديهم مفردات أصغر ، خاصة عندما يمكنهم فعل الكثير؟ حسنًا ، اتضح أنه ، في العالم المادي ، من الملائم أن تكون قادرًا على تمثيل حالتين فقط بدلاً من 10. وبالحالات ، أعني الأرقام ، في هذه الحالة. من الأسهل كثيرًا في عالم البشر ، عدم تمثيل 10 قيم محتملة 0 أو 9 ، ولكن فقط اثنين - 0 و 1. ويمكننا أن نطلق على هذه الأرقام أي شيء نريده ، لكننا نحن البشر وحدنا أرقامنا من هذا القبيل. لكن 0 و 1 لطيفان لأنك إذا كنت تعتقد أن أحد هذه الأرقام أو البتات الثنائية مجرد مصباح كهربائي - فهو إما مطفأ أو مضاء. يمكنك التفكير في الرقم 0 على أنه مصباح كهربائي مطفأ والآخر على أنه مصباح كهربائي قيد التشغيل. والمصابيح الكهربائية ، بالطبع ، في عالمنا البشري تحتاج فقط إلى الكهرباء لتشغيلها.

And so, if we somehow get electricity into our computer laptop, desktop, or whatnot coming from the power outlet in the wall or some battery, well, that would seem to be sufficient input in order to turn a light bulb on or off, to turn a switch, really, on or off. And indeed, that's what's inside of our computers-- transistors, otherwise known as switches. And these transistors, which now number in the billions in the most modern of computers are tiny, tiny, tiny little light switches, if you will, that, if turned on, allow us to store 1s, if turned off, allow us to store 0s. And using those many, many, many transistors, can we store values, can we store data, can we compute, and can we actually do everything we can today with our modern computers. Let's make this more real and try out some actual light bulbs. So here are some light bulbs clamped into these desk lamps. And suppose now that I have these light bulbs here to represent bits or binary digits. So each of these light bulbs can represent a 0 if it's

off or a 1 if it's on. And if we think about the same system that computers use, let's think of this bulb here as being the one's place, this bulb here as being the two's place and this bulb here as being the four's place. So what number am I currently representing if all of these light bulbs are off? Well, that's like having 0, 0, 0. Since they're all off, so that's the number we humans know in decimal, dec meaning 10, as 0. What about if I turn on just this one light bulb here? What does that represent? This, again, is the one's place, the two's place, and the four's place. So this, of course, represents the number we know as 1. Now, if I go ahead and simultaneously switch these, this is still the one's place, the two's place, and the four's place.

وهكذا ،

إذا حصلنا بطريقة ما على الكهرباء في جهاز الكمبيوتر المحمول ، أو سطح المكتب ، أو ما لا يأتي من مأخذ الطاقة في الحائط أو بعض البطاريات ، حسنًا ، فسيبدو هذا إدخالًا كافيًا لتشغيل المصباح الكهربائي أو إيقاف تشغيله ، تشغيل مفتاح أو إيقاف تشغيله حقًا. وبالفعل ، هذا ما بداخل أجهزة الكمبيوتر لدينا - الترانزستورات ، والمعروفة أيضًا بالمفاتيح. وهذه الترانزستورات ، التي يبلغ عددها الآن المليارات في أكثر أجهزة الكمبيوتر حداثة ، هي مفاتيح صغيرة جدًا ، صغيرة جدًا ، ومفاتيح ضوئية صغيرة جدًا ، إذا صح التعبير ، والتي ، إذا تم تشغيلها ، تسمح لنا بتخزين s1 ، إذا تم إيقاف تشغيلها ، تسمح لنا بالتخزين 0 ثانية. وباستخدام العديد والعديد من الترانزستورات ، هل يمكننا تخزين القيم ، هل يمكننا تخزين البيانات ، هل يمكننا الحساب ، ويمكننا فعلاً فعل كل ما في وسعنا اليوم باستخدام أجهزة الكمبيوتر الحديثة. لنجعل هذا أكثر واقعية ونجرب بعض مصابيح الإضاءة الفعلية. إذن ها هي بعض المصابيح الكهربائية مثبتة في مصابيح المكتب هذه. افترض الآن أن لديّ هذه المصابيح هنا لتمثيل وحدات البت أو الأرقام الثنائية. لذلك يمكن لكل من هذه المصابيح أن تمثل 0 إذا كانت متوقفة أو 1 إذا كانت قيد التشغيل. وإذا فكرنا في نفس النظام الذي تستخدمه أجهزة الكمبيوتر ، فلنفكر في هذا المصباح هنا على أنه مكان الشخص ، هذا المصباح هنا هو مكان الاثنين وهذا المصباح هنا هو مكان

الأربعة. إذن ما هو الرقم الذي أمثله حاليًا إذا كانت كل هذه المصابيح متوقفة؟ حسنًا ، هذا يشبه الحصول على 0 ، 0 ، 0. نظرًا لأنهم جميعًا متوقفون عن العمل ، فهذا هو الرقم الذي نعرفه نحن البشر في النظام العشري ، وهو Dec يعني 10 ، مثل 0. ماذا لو قمت بتشغيل هذا المصباح الكهربائي هنا؟ ماذا يمثل ذلك؟ هذا ، مرة أخرى ، هو خانة الآحاد وخانة الاثنين وخانة الأربعة. لذلك ، هذا ، بالطبع ، يمثل الرقم الذي نعرفه بالرمز 1. الآن ، إذا تقدمت وقمت بتبديلها في نفس الوقت ، فلا يزال هذا هو خانة الآحاد ، وخانة الاثنين ، وخانة الأربعة.

Consider the decimal number (what we human typically use) 123	**The rightmost column is the 1s column** **The middle, the 10s** **The leftmost, the 100s**
100 | 10 | 1 1 | 2 | 3	**Thus, we have** 100 x 1 + 10 x 2 + 1 x 3 = 100 + 20 + 3 = 123

Inside a computer, the binary 000 would represent 0, just like in our human world!	
However, in this case we are dealing with binary so: 4 | 2 | 1 0 | 0 | 0	**The right most column is the 1s place** **The middle, the 2s** **The leftmost, the 4s**
In the human world (decimal) we use powers of 10 for place values	$10^0 = 1$, $10^1 = 10$, $10^2 = 100$, $10^3 = 1000$**, etc.**
In the computer world (binary) we use powers of 2 for place values	**$2^0 = 1$, $2^1 = 2$, $2^2 = 4$, $2^3 = 8$, etc.**
The difference between decimal numbers and binary numbers is changing the base	**For the binary number 000, we have** 4 x 0 + 2 x 0 + 1 x 0 = 0 + 0 + 0 = 0**!**

Consider the binary number 001:

4	2	1
0	0	1

We have 4 x 0 + 2 x 0 + 1 x 1 = 0 + 0 + 1 = 1

How do we represent the decimal number 2 in binary?

We don't need a 4, be we need a 2, and also no 1

4	2	1
0	1	0

This gives us 4 x 0 + 2 x 1 + 1 x 0 = 0 + 2 + 0 = 2

Likewise, the number 3 would be:

As we need a 2 and a 1

4	2	1
0	1	1

Thus, 4 x 0 + 2 x 1 + 1 x 1 = 0 + 2 + 1 = 3

Similarly, 4 would be:

4	2	1
1	0	0

What about 7?

4	2	1
1	1	1

Which yields 4 x 1 + 2 x 1 + 1 x 1 = 4 + 2 + 1 = 7

What about 8?

We can't count to 8 without another bit (binary digit)

We run into this in the real world too if we need a four-digit number vs a 3-digit number

Start with the 1s, 10s, 100s place and add the 1000s

Here we'll add the next power of 2, 8

8	4	2	1
1	0	0	0

8 x 1 + 4 x 0 + 2 x 0 + 1 x 0 = 8

Even though computers only use binary, they can count as high as humans can!

They do it with a smaller vocabulary, just 1 and 0.

This is because it's easier to represent two states in the physical world.

If you think of one of these bits as being a light bulb:	0 is off 1 is on
Light bulbs just need electricity to turn on or off	Electricity is sufficient to turn a switch on or off
Inside a computer exists these switches called transistors	Modern computers have billions!
Turned **off** represents **0**	Turned **on** represents **1**

Using these transistors we can store values, store data, compute, and do everything we can with computers

David demonstrates how transistors work using light bulbs

So far, all that we can represent is numbers

A decision needs to be made on what pattern of 1s and 0s to represent letters, words, and paragraphs

All computers can store is 0s and 1s	To represent letters, we need a mapping of 0s and 1s to characters

ASCII (American Standard Code for Information Interchange) does this

0	NUL	16	DLE	32	SP	48	0	64	@	80	P	96	`	112	p
1	SOH	17	DC1	33	!	49	1	65	A	81	Q	97	a	113	q
2	STX	18	DC2	34	"	50	2	66	B	82	R	98	b	114	r
3	ETX	19	DC3	35	#	51	3	67	C	83	S	99	c	115	s
4	EOT	20	DC4	36	$	52	4	68	D	84	T	100	d	116	t
5	ENQ	21	NAK	37	%	53	5	69	E	85	U	101	e	117	u
6	ACK	22	SYN	38	&	54	6	70	F	86	V	102	f	118	v
7	BEL	23	ETB	39	'	55	7	71	G	87	W	103	g	119	w
8	BS	24	CAN	40	(	56	8	72	H	88	X	104	h	120	x
9	HT	25	EM	41	)	57	9	73	I	89	Y	105	i	121	y
10	LF	26	SUB	42	*	58	:	74	J	90	Z	106	j	122	z
11	VT	27	ESC	43	+	59	;	75	K	91	[	107	k	123	{
12	FF	28	FS	44	,	60	<	76	L	92	\	108	l	124	|
13	CR	29	GS	45	-	61	=	77	M	93	]	109	m	125	}
14	SO	30	RS	46	.	62	>	78	N	94	^	110	n	126	~
15	SI	31	US	47	/	63	?	79	O	95	_	111	o	127	DEL

65 -> A, 66 -> B, 67 -> C, etc.	97 -> a, 98 -> b, 99 -> c, etc.

ASCII also has mapping for punctuation symbols

Programs like **notepad**, **TextEdit**, and **Microsoft Word** decide whether to display patterns of bits as letters or words

Computers only store 0s and 1s, but the programs interpret those bits in a certain way	**For example,** if Microsoft word sees a pattern of buts representing the number 65, it will interpret that as "A"

ASCII is limited

Original ASCII is 7 bits, thus giving 128 characters	Extended ASCII is 8 bits, yielding 256 characters	Many symbols are not represented

UNICODE is a bigger set of characters that includes written languages other than English and even emoji! 😳

All are still represented by a pattern of bits	Consider this pattern of bits: 01001000 01001001	16 bits or 2 bytes (**1 byte = 8 bits**)

Using ASCII, we get the word "**HI**"

128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	1
1 * 64 + 1 * 8								1 * 64 + 1 * 8 + 1 * 1							
72								73							
H								I							

CPU

If you have heard that your computer has “Intel Inside,” it has an Intel processor in it

The backside of the processor has pins that connect into the motherboard

The motherboard is a circuit board made of silicon

The CPU is the brain of the computer

Does all the thinking

Performs math in numbers fed to it

Helps display numbers on a screen

Adds or deletes numbers

CPUs now can have multiple cores

Cores are the devices inside the CPU that can perform mathematical operations, load info from memory, save info to memory, etc.

The more cores, the more tasks a CPU can do at once

CPUs now also support hyper-threading

Where a single core will present itself as multiple cores to a computer’s

operating system

Systems on a Chip (SoaC) are when a CPU and more are all interconnected at once rather than attached to a motherboard

Popular in phones, tables, and game consoles

Raspberry Pi

RAM (Random Access Memory)

Circuit board with chips that slides into a slot on the motherboard

The chips store data: Only stores data when the power is on

Files and programs are loaded onto these chips when ran

Fast memory

You can check your RAM and other specs:

Windows Task Manager

CPU chart shows when peak usage occurs

GHz is the number of operations a CPU can perform per second (in billions)

1.94 GHz = 1.94 billion operations per second

Logical processors in this case is 4, which means both cores support hyper-threading

Each core will do two things at once as if 4 cores

exist

Mac System Profiler

Hardware Overview:

Model Name:	MacBook Pro
Model Identifier:	MacBookPro12,1
Processor Name:	Intel Core i7
Processor Speed:	3.1 GHz
Number of Processors:	1
Total Number of Cores:	2
L2 Cache (per Core):	256 KB
L3 Cache:	4 MB
Memory:	16 GB

Hard Drives

When you turn a computer off, you need a place to store data

A hard disk drive (HDD) stores this information

RAM may store 1 GB, 2 GB, 4 GB, through 16 GB or so

HDD stores 256 GB, 1024 GB (AKA terabyte or TB), 2 TB

Inside a HDD, metal platters physically spin around

Data is stored on these disks

The reading heads move back and forth reading data from the device

Uses tiny magnetic particles where north pole orientation represents 1 and south pole orientation represents 0	Power is only needed to read or change the data Data is preserved when power is off

- David shows a video of a HDD running in slowmo
- To store data in a hard drive, RAM sends data and instructions to the HDD
  - The hard drive translates that data into voltage fluctuations
    - Some signals spin the platters, others move the read/write heads
    - Pulses sent to the read/write head turn on a magnet which creates a field that changes the polarity of a tiny portion of the metal platter's surface
    - Power is sent in different directions as to change polarity
  - To read, the particles on the disk use their charge to move the read/write head.
  - Pieces of a file can be spread out around the platters
    - A special file keeps track of data's location
  - Anytime you have a physical device that moves over a period of time, things go wrong
    - Dropping a HDD can corrupt files
  - Platters spin slower than how fast electrons move

Flash Memory

- Solid state disk (SSD)

- Smaller (3.5 inch width for HDD vs 2.5 inch width for SSD)
  - Still fits where old HDDs are
- No moving particles
- Inside, it looks a lot like RAM

- Much faster than HDD
  - Programs/files load and save more quickly
- SSD theoretically don't last as long as HDD
  - Finite number of writes

- Hybrid Drives
  - Some GB of solid state memory and more GB or TB of HDD space
  - Stores as much of frequently-needed data on the SSD
  - Stores less frequently-needed data on HDD
- Flash memory also exists in the form of USB sticks
  - Might store 1 GB, 16 GB, or more
  - Portable
- External SSDs exist for more storage
  - Might store 256 GB or more
  - Can be used to share data with others without network usage
- Can also have external HDD

Types of Memory and Funneling

- There is a tradeoff between space, money, and speed of data transfer

- Data is pushed “down the funnel” to your CPU
  - From the hard drive, data first goes to the RAM

  - Theoretically, the CPU never has to wait for data to crunch
  - There is a tiny amount of memory (bytes) called registers where numbers are stored for operations.
  - Memory at the bottom is more expensive
  - Disk is important for the long-term storage
  - RAM is important as it stores programs you use simultaneously
  - L3, L2, L1 cache are on the motherboard
- As an analogy for memory, picture a candy store
  - A customer approaches the counter and requests candy

- The shop owner then leaves the counter to grab the candy before returning moments later
    - Not super efficient to walk all the way to the store room to grab candy
        - Better to have a cache of memory
- Instead, the shop owner leaves the counter to ready a cache of candy before the customers arrive
- When a customer comes, the candy can be distributed quickly
    - Cache memory similarly helps the CPU in this manner

- We can see sizes of cache looking at computer specs like before

Display Connectors

- These sockets all connect to monitors or displays
- Mini DisplayPort are used form monitors
- HDMI is not only on laptops and computers but also TVs
- VGA is older, but still commonly uses on projectors

USB (Universal Serial Bus)

- **Can plug in a whole range of peripheral devices including printers, keyboards, mice, scanners, etc.**
- **USB-A most common**
- **USB-B is often used for printers and scanners**
- **USB-C is newer and can be plugged in coming from different directions**
- **Other variants often exist for phones**
- **Older USB connections are slower when transferring data**
    - **Hard drives can connect via USB**
        - **Even if a hard drive is fast, if the USB is slow, the transfer of data will be slow**

Wireless

- **Wifi is wireless internet**
- **Bluetooth allows devices such as wireless keyboards and headphones to connect to your computer**
    - **Limited range**
        - **This is ok as it is used for you to connect to your own device**

Operating System (OS)

- **Software that ensures all devices work and can intercommunicate**

- **MacOS and Windows are popular OS**
- **Can be installed by the user, but is typically done so by a manufacturer**
    - **Installed on HDD or SDD so that it exists persistently without power**
- **When you hit power on your computer, the OS is loaded into RAM**
- **Gives you the graphical interface that you see**
- **Knows how to:**
    - **Talk to your keyboard and mouse**
    - **Display info on the screen**
    - **Move things around in memory**
- **This is all thanks to device drivers installed with the OS**
    - **Special software designed to talk to certain model of printer, camera, scanner, etc.**
- **When an OS doesn't recognize a device, perhaps because it's too new, you can download new device drives from the device manufacturer**
    - **Teaches Window, MacOS, or Linux about that new hardware**
    - **Future-proofing structure**
- **It's this intersection of hardware and software that makes computers powerful!**

Looking Underneath the Hood

- **David and Colton Ogden look at the exterior of an old ThinkPad computer, examining ports**
    - **Power bricks convert power from the wall into safe amounts for the computer**
- **David and Colton examine the inside of an old window desktop, highlighting the motherboard, heatsink, RAM, Hard Drive, etc.**
- **David and Colton then look inside a HDD**
    - **Once exposed to air and dust, it's no longer reliable enough to use**
- **David and Colton then look at a motherboard examining all the ports on it**

What are you hoping to get out of this course?

Your answer

If, like me, you sometimes count using your fingers, odds are you can count up to 5 things on one hand (using 5 fingers). But that's if you're using "unary" notation, whereby you only have a single digit (pun intended) at your disposal, a finger, which you can think of as a 1. Binary, by contrast, allows you to use two digits, 0 and 1. How high could you count on one hand (with 5 fingers) using binary? Assume that a raised finger represents a 1 and a lowered finger represents a 0.

1 point

Your answer

Recall that we looked at ASCII in lecture, which uses just 7 or 8 bits to represent letters of the alphabet. Read up on "Unicode," as via Google, and explain in your own words how Unicode is able to represent many more symbols than can ASCII, which is particularly helpful for written languages with many more characters than English.

1 point

Your answer

01000001 01101110 01110011 01110111 01100101 01110010 00100000 01101001 01110011 00100000 00110100 00110010 00101110

There's a way to make this meaningful; find it!

1 point

Your answer

Describe at least one key difference, other than size/storage capacity, between RAM and hard disk.

1 point

Your answer

Some computers, particularly PCs, come with stickers that say "Intel Inside." What is it that's inside of most computers that's made by Intel? In your own words, what does that hardware do?

1 point

Your answer

Roughly how much RAM might a new laptop come with these days?

1 point

Your answer

Roughly how much disk space might a new laptop come with these days?

1 point

Your answer

Name a single device that can be connected to a laptop or desktop via "USB".

1 point

Your answer

What purpose does a device driver serve?

1 point

Your answer

Even though both are wireless, how does Wi-Fi differ from Bluetooth? You're welcome to Google as needed, but take care to distinguish the two in your own words.

So what is this? This, now, is the number we know as 2. How do I count as high as 3? I don't want to keep going down the line. Instead, I want to turn this 1 back on because that means I get a 1 plus a 2. I don't need the 4, which is great, because now I have 3. How do I get to 4 then? Well, let me turn both of these off, turn this one on, and now, of course, this is the four's place. So this is a 4. If I turn this one back on, now we're up to a four's place and a one's place, so that gives me 5. If I turn this off, this on, that gives me a 4 plus a 2, or a 6. And finally, if that turns on, I have now a 7. Unfortunately, I can't count as high as 8 unless I go get myself another desk lamp, but for that we just need another bit. But this is all very fine and good, but all I can represent thus far, it seems, are numbers. How, though, do I represent letters of the actual alphabet, A through Z? How do I represent words or paragraphs, let alone emails, and any number of other features that computers today support? Well, for that, we're going to need to make a decision.

إذن ما هذا؟

هذا ، الآن ، هو الرقم الذي نعرفه على أنه 2. كيف أحسب ارتفاعًا يصل إلى 3؟ لا أريد أن أستمر في النزول إلى أسفل الخط. بدلاً من ذلك ، أريد إعادة تشغيل هذه القيمة 1 لأن هذا يعني أنني أحصل على 1 زائد أ 2. لست بحاجة إلى 4 ، وهو أمر رائع ، لأن لدي الآن 3. كيف يمكنني الوصول إلى 4 بعد ذلك؟ حسنًا ، دعني أطفئ كلاهما ، وتشغيل هذا ، والآن ، بالطبع ، هذا هو الخانة الأربعة. هذه هي 4. إذا أعدت تشغيل هذا ، فسنصل الآن إلى خانة أربعة وخانة واحدة ، وهذا يعطيني 5. إذا أوقفت هذا ، فهذا يعطيني 4 زائد a2 ، أو 6. وأخيرًا ، إذا تم تشغيل ذلك ، فلدي الآن 7. لسوء الحظ ، لا يمكنني العد حتى 8 ما لم أحضر لنفسي مصباحًا مكتبيًا آخر ، لكن من أجل ذلك نحتاج فقط إلى جزء آخر. لكن كل هذا جيد وجيد للغاية ، ولكن يبدو أن كل ما يمكنني تمثيله حتى الآن هو الأرقام. ولكن كيف يمكنني تمثيل حروف الأبجدية الفعلية ، من الألف إلى الياء؟ كيف أمثل الكلمات أو الفقرات ، ناهيك عن رسائل البريد الإلكتروني ، وأي عدد من الميزات الأخرى التي تدعمها أجهزة الكمبيوتر اليوم؟ حسنًا ، لذلك ، سنحتاج إلى اتخاذ قرار.

We're going to need to decide what patterns of bits to use to represent those higher level notions like letters words and paragraphs. So for that, I've got an idea. So at the end of the day, all computers can store is, indeed, 0s and 1s. And from those zeros and ones, of course, can we count higher so long as we have a mapping from binary to the numbers we know as decimal. But, of course, we want our computers to do more. We want to be able to express words and even other types of data. So how do we do that? Well, we need to come up with a standardization, a

mapping, from 0s and 1s, or really just numbers, to the letters that we want. And it turns out, that some years ago what humans decided to do was this. Now, at first glance, this might be a little overwhelming. This is just a screenshot of a chart from asciichart.com. An ASCII chart is a chart of ASCII characters, American Standard Code for Information Interchange. And this is simply a mapping from decimal numbers to letters. And so on let's notice a few of these. Notice here that 65 apparently maps to A, 66 maps to B, 67 maps to C, and so forth. Meanwhile, 97 maps to lowercase a, 98 to lowercase b, 99 to lowercase c, and so forth. And there's also mappings from punctuation symbols to all the letters of the alphabet that you may know. So why is this significant? Well, it turns out that even though computers only store 0s and 1s, we, of course, use them in different ways. We have programs like Notepad on PCs, or TextEdit on Mac OS, or Microsoft Word on both platforms, or Google spreadsheets, or Google Docs, or the like. And so we have all these different programs that is designed to do one thing or the other. And so those programs essentially decide, in their own context, whether to display patterns of bits as numbers or as letters or, in turn, words and paragraphs. So it's entirely context-dependent.

سنحتاج إلى تحديد أنماط البتات التي يجب استخدامها لتمثيل مفاهيم المستوى الأعلى مثل كلمات الحروف والفقرات. لذلك ، لدي فكرة. لذا في نهاية اليوم ، جميع أجهزة الكمبيوتر التي يمكن تخزينها هي بالفعل 0 و 1. ومن هذين الأصفار والآحاد ، بالطبع ، يمكننا العد أعلى طالما لدينا تعيينًا من النظام الثنائي إلى الأرقام التي نعرفها على أنها عشرية. لكن ، بالطبع ، نريد أن تقوم أجهزة الكمبيوتر لدينا بالمزيد. نريد أن نكون قادرين على التعبير عن الكلمات وحتى أنواع البيانات الأخرى. فكيف لنا أن نفعل ذلك؟ حسنًا ، نحن بحاجة إلى التوحيد القياسي ، ورسم الخرائط ، من 0 و 1 ، أو مجرد أرقام ، إلى الأحرف التي نريدها. واتضح أنه منذ بضع سنوات ما قرر البشر القيام به كان هذا. الآن ، للوهلة الأولى ، قد يكون هذا مربكًا بعض الشيء. هذه مجرد لقطة شاشة لرسم بياني من asciichart.com. مخطط ASCII هو مخطط لأحرف ASCII ، الكود القياسي الأمريكي لتبادل المعلومات. وهذا مجرد تعيين من الأرقام العشرية إلى الأحرف. وهكذا دعونا نلاحظ القليل من هؤلاء. لاحظ هنا أن 65 خريطة على ما يبدو لـ A و 66 خريطة إلى B و 67 خريطة إلى C وهكذا دواليك. وفي الوقت نفسه ، هناك 97 خريطة بالأحرف الصغيرة a ، و 98 إلى الأحرف الصغيرة b ، و 99 إلى الأحرف الصغيرة c ، وهكذا دواليك. وهناك أيضًا تعيينات من رموز الترقيم إلى جميع أحرف الأبجدية التي قد تعرفها. فلماذا هذا مهم؟ حسنًا ، اتضح أنه على الرغم من أن أجهزة الكمبيوتر تخزن 0 و 1 فقط ، فإننا بالطبع نستخدمها بطرق مختلفة. لدينا برامج مثل Notepad على أجهزة الكمبيوتر ، أو TextEdit على نظام Mac OS ، أو Microsoft Word على كلا النظامين الأساسيين ، أو جداول بيانات Google ، أو مستندات Google ، أو ما شابه ذلك. ولذا لدينا كل هذه البرامج المختلفة المصممة للقيام بشيء أو

بآخر. وبالتالي فإن هذه البرامج تقرر بشكل أساسي ، في سياقها الخاص ، ما إذا كانت ستعرض أنماط البتات كأرقام أو كأحرف أو ، بدورها ، كلمات وفقرات. لذلك فهي تعتمد على السياق تمامًا.

At the end of the day, all the computer is storing is 0s and 1s, but it's up to the program to interpret those 0s and 1s in a certain way. And so, if a program like Microsoft Word or Google Docs sees a pattern of bits in a file that represents the decimal number 65-- it's still pattern of 0s and 1s expressed in binary, but of course, we've seen how we can convert that to decimal. So if a computer is ultimately storing a pattern of 0s and 1s that represents the decimal number 65, the computer, in this case Microsoft Word, or Google Docs, and the program running there, is going to interpret that pattern, not as the number 65, and not as a whole bunch of 0s and 1s alone, but as the capital letter A. And that's what you'll see on your screen. If it, instead, sees a pattern of bits that represents the decimal number 66, Microsoft Word or Google Docs is going to show, instead, the capitol letter B. If the pattern of bits instead represents the decimal number 97, that program is going to display the lowercase letter a or any number of other letters from the alphabet.

في نهاية اليوم ،

كل ما يخزنه الكمبيوتر هو 0 و 1 ، لكن الأمر متروك للبرنامج لتفسير تلك 0 و 1 بطريقة معينة. وهكذا ، إذا رأى برنامج مثل Microsoft Word أو Google Docs نمطًا من البتات في ملف يمثل الرقم العشري 65 - لا يزال نمطًا من 0 و 1 معبرًا عنه بالثنائي ، ولكن بالطبع ، رأينا كيف يمكننا تحويل ذلك إلى رقم عشري. لذلك إذا كان الكمبيوتر يخزن في النهاية نمطًا من 0 و 1 يمثل الرقم العشري 65 ، فإن الكمبيوتر ، في هذه الحالة Microsoft Word ، أو محرر مستندات Google ، والبرنامج الذي يعمل هناك ، سوف يفسر هذا النمط ، وليس الرقم 65 ، وليس كمجموعة كاملة من 0 و 1 فقط ، ولكن كحرف كبير A. وهذا ما ستراه على شاشتك. إذا رأى ، بدلاً من ذلك ، نمطًا من البتات يمثل الرقم العشري 66 ، فسيعرض برنامج Microsoft Word أو محرر مستندات Google ، بدلاً من ذلك ، حرف الكابيتول ب. لعرض الحرف الصغير a أو أي عدد من الأحرف الأخرى من الأبجدية.

And so we just had to decide in advance what mapping to use, what code to use that maps numbers to letters. And in fact, you'll notice that quite a few characters are absent from the screen here. In fact, if you speak some language and write some language other than English there might be some characters that you can express with just this range of values. In fact ASCII originally only used 7 bits total. Or if you round up, 8 bits total, for what's called the extended ASCII. And it turns out, that's not nearly enough patterns of bits, 256 maximally, that you can use to express characters that you might see in certain Asian

languages or symbols that just simply are not depicted even yet on the screen here. So there are other systems, not just ASCII.

ولذا كان علينا فقط أن نقرر مقدمًا ما هو التعيين الذي يجب استخدامه ، وما هو الرمز الذي يجب استخدامه لتعيين الأرقام إلى الأحرف. وفي الواقع ، ستلاحظ غياب عدد غير قليل من الشخصيات عن الشاشة هنا. في الواقع ، إذا كنت تتحدث لغة ما وتكتب لغة أخرى غير الإنجليزية ، فقد تكون هناك بعض الأحرف التي يمكنك التعبير عنها باستخدام هذا النطاق من القيم فقط. في الواقع ، استخدم ASCII في الأصل إجمالي 7 بت فقط. أو إذا قمت بالتقريب ، إجمالي 8 بت ، لما يسمى ASCII الممتد. واتضح أن هذه ليست أنماطًا كافية تقريبًا ، 256 كحد أقصى ، يمكنك استخدامها للتعبير عن الأحرف التي قد تراها في بعض اللغات أو الرموز الآسيوية التي لم يتم تصويرها حتى الآن على الشاشة هنا. لذلك هناك أنظمة أخرى ، وليس ASCII فقط.

Something called Unicode, for instance, is a superset of what you see here. And that actually allows us to express any number of characters from English and Asian languages and beyond and, in fact, even things like the emoji characters-- the smiley faces, and other such characters that you might now use increasingly on your phone, your desktop, or laptop. Those two are expressed ultimately as just patterns of bits. And the world, for the most part, has simply standardized on what pattern of bits represents a happy face, what pattern of bits represents a sad face, and beyond, in that system there is Unicode. So let's take an example. Suppose that you see this pattern of bits somewhere in a file. And you, in this context, say are Microsoft Word, or Google Docs, or some program designed to display, not numbers like a calculator, but words and letters like a word processor or a text editor. Well, what is this pattern of bits? Well, we haven't seen this many bits before, but it looks to be like two patterns of eight.

شيء ما يسمى Unicode ،

على سبيل المثال ، هو مجموعة شاملة لما تراه هنا. وهذا في الواقع يسمح لنا بالتعبير عن أي عدد من الأحرف من اللغة الإنجليزية واللغات الآسيوية وما وراء ذلك ، وفي الواقع ، حتى أشياء مثل أحرف الرموز التعبيرية - الوجوه المبتسمة ، وغيرها من الشخصيات التي قد تستخدمها الآن بشكل متزايد على هاتفك ، سطح المكتب أو الكمبيوتر المحمول. يتم التعبير عن هذين النوعين في النهاية على أنهما مجرد أنماط من البتات. والعالم ، في الغالب ، قد قام ببساطة بتوحيد نمط البتات الذي يمثل وجهًا سعيدًا ، ونمط البتات الذي يمثل وجهًا حزينًا ، وما وراء ذلك ، في هذا النظام يوجد Unicode. لنأخذ مثالا. افترض أنك ترى هذا النمط من البتات في مكان ما في الملف. وأنت ، في هذا السياق ، تقول Microsoft Word ، أو Google Docs ، أو بعض البرامج المصممة للعرض ، وليس

الأرقام مثل الآلة الحاسبة ، ولكن الكلمات والحروف مثل معالج الكلمات أو محرر النصوص. حسنًا ، ما هو هذا النمط من البتات؟ حسنًا ، لم نر هذه البتات العديدة من قبل ، لكن يبدو أنها تشبه نمطين من ثمانية.

And in fact, it turns out that anytime you have eight bits here or eight bits here, humans generally refer to this as a byte, B-Y-T-E. So a byte is just eight bits. And it's a slightly more useful measure because it's a lot bigger than a single bit, which can, of course, only represent 0 or 1. A byte can actually count higher. So what are the columns here if we look only at this number at left? This is my 1's place, 2's, 4's, 8's, 16's, 32's, and 64, and then 128. So in which of these columns do I actually have values? I seem to have a 1 in the 64's place. And I seem to have a 1 in the 16's place. So 64 plus 16, if I do that arithmetic, that gives me 72. So this pattern of bits on the left here, seems to be representing the number 72. Now let's consider the pattern of bits on the right. Again, my 1's place, 2's place, 4's 8's, 16's, 32, 64, 128. Now notice, these patterns are actually almost identical. We've got a 1 in the 64's place, we've got a 1 in the 16's place, but we've also got an extra one in the 1's place. So if this was 72, and this pattern is identical except for this last bit here, which adds 1, this must be 72 followed by 73. And I've put a space here, visually, just to separate the fact that these are, indeed, two separate bytes.

وفي الحقيقة ،

اتضح أنه في أي وقت يكون لديك ثماني بتات هنا أو ثماني بتات هنا ، يشير البشر عمومًا إلى هذا على أنه بايت ، B-Y-T-E. إذن فالبايت يساوي ثمانية بتات فقط. وهو مقياس أكثر فائدة إلى حد ما لأنه أكبر بكثير من بت واحد ، والذي ، بالطبع ، يمكن أن يمثل فقط 0 أو 1. يمكن للبايت في الواقع أن يعد أعلى. إذن ما هي الأعمدة هنا إذا نظرنا إلى هذا الرقم على اليسار فقط؟ هذا هو مكاني 1 و 2 و 4 و 8 و 16 و 32 و 64 ثم 128. إذن في أي من هذه الأعمدة لدي قيم بالفعل؟ يبدو أن لدي 1 في مكان 64. ويبدو أن لدي الرقم 1 في خانة 16. إذن 64 زائد 16 ، إذا قمت بهذا الحساب ، فهذا يعطيني 72. إذن هذا النمط من البتات على اليسار هنا ، يبدو أنه يمثل الرقم 72. الآن دعونا ننظر في نمط البتات على اليمين. مرة أخرى ، مكاني 1 ، خانة 2 ، 4 ، 8 ، 16 ، 32 ، 64 ، 128. لاحظ الآن أن هذه الأنماط متطابقة تقريبًا. لدينا 1 في خانة 64 ، لدينا 1 في خانة 16 ، لكن لدينا أيضًا واحدًا إضافيًا في خانة الآحاد. إذا كان هذا 72 ، وكان هذا النمط متطابقًا باستثناء الجزء الأخير هنا ، والذي يضيف 1 ، يجب أن يكون 72 متبوعًا بـ 73. وقد وضعت مسافة هنا ، بصريًا ، فقط لفصل حقيقة أن هذه ، في الواقع ، اثنان بايت منفصلان.

And I claim now that, yes, while you could interpret these as two decimal digits, 72 and 73, it turns out, per the ASCII system, we could map 72 and 73 to alphabetical letters. What might those

letters be? Well, if we consider our chart again, 72 apparently gives us a capital H. 73 gives us the capital I. And, voila, 72 followed by 73 in a computer's memory, apparently, is how a computer would express HI. And of course, if we used more bytes, and therefore more bits, and therefore more numbers, we could represent even larger words than just H I, or HI. But that's exactly how a computer, underneath the hood so to speak, would store a word like HI. Now what is indeed using these patterns of bits? And what is a computer actually doing at the end of the day? Well, for that, we need to take a look under the hood, so to speak. This is what Intel inside means. If your Mac or your PC comes with an Intel Inside, as goes the marketing slogan, that means that your computer has inside of it a CPU, a Central Processing Unit that looks a little something like this. It's a pretty small device. It's not quite as big as this. This, of course, is not to scale.

وأدعي الآن أنه ، نعم ،

بينما يمكنك تفسير هذين الرقمين العشريين ، 72 و 73 ، اتضح أنه وفقًا لنظام ASCII ، يمكننا تعيين 72 و 73 لأحرف أبجدية. ماذا يمكن أن تكون هذه الحروف؟ حسنًا ، إذا نظرنا إلى الرسم البياني مرة أخرى ، من الواضح أن 72 يعطينا رأس المال H.73 يعطينا رأس المال I. و voila، 72 متبوعًا بـ 73 في ذاكرة الكمبيوتر ، على ما يبدو ، هي الطريقة التي يعبر بها الكمبيوتر عن HI. وبالطبع ، إذا استخدمنا المزيد من البايت ، وبالتالي المزيد من البتات ، وبالتالي المزيد من الأرقام ، فيمكننا تمثيل كلمات أكبر من مجرد H I أو HI. ولكن هذا هو بالضبط كيف يخزن الكمبيوتر ، تحت الغطاء ، إذا جاز التعبير ، كلمة مثل HI. الآن ما الذي يستخدم بالفعل أنماط البتات هذه؟ وماذا يفعل الكمبيوتر بالفعل في نهاية اليوم؟ حسنًا ، من أجل ذلك ، نحتاج إلى إلقاء نظرة تحت الغطاء ، إذا جاز التعبير. هذا ما تعنيه إنتل من الداخل. إذا كان جهاز Mac أو جهاز الكمبيوتر الخاص بك مزودًا بـ Intel Inside ، كما هو الحال مع شعار التسويق ، فهذا يعني أن جهاز الكمبيوتر الخاص بك يحتوي بداخله على وحدة المعالجة المركزية ، وحدة المعالجة المركزية التي تبدو مثل هذا قليلاً. إنه جهاز صغير جدًا. انها ليست كبيرة مثل هذا. هذا ، بالطبع ، ليس مقياسًا.

It wouldn't fit in your actual laptop or desktop. But what you see is two sides. This is just a mental case and a nice big logo there. And then, if you flip this around, you see the other side, which generally has a whole bunch of golden pins that actually interconnect to a device inside of the computer. And now what is that device? Well, that device, we'll soon see, is something called the motherboard. A motherboard is a circuit board, so a big piece of silicon or plastic-like material that has a lot of lines running back and forth on it, and often has sockets, essentially, a bunch of tiny little holes into which devices like this fit so that you can put this inside of a computer and

actually have it clamped down on something. Now what does it mean to be a CPU? Well, the CPU is the brains of your computer. It's the thing in your computer that does all of the work, all of the thinking. Now what kind of thinking does a computer need to do?

لن يتناسب مع الكمبيوتر المحمول أو سطح المكتب الفعلي.

لكن ما تراه هو وجهان. هذه مجرد حالة ذهنية وشعار كبير لطيف هناك. وبعد ذلك ، إذا قلبت هذا ، فسترى الجانب الآخر ، والذي يحتوي عمومًا على مجموعة كاملة من المسامير الذهبية التي تتصل فعليًا بجهاز داخل الكمبيوتر.

والآن ما هو هذا الجهاز؟ حسنًا ، هذا الجهاز ، سنرى قريبًا ، هو شيء يسمى اللوحة الأم. اللوحة الأم عبارة عن لوحة دوائر كهربائية ، لذلك قطعة كبيرة من السيليكون أو مادة شبيهة بالبلاستيك تحتوي على الكثير من الخطوط التي تتحرك ذهابًا وإيابًا عليها ، وغالبًا ما تحتوي على مآخذ ، بشكل أساسي ، مجموعة من الثقوب الصغيرة التي تناسب أجهزة مثل هذه بحيث يمكنك وضع هذا داخل جهاز كمبيوتر وتثبيته بالفعل على شيء ما. الآن ماذا يعني أن تكون وحدة المعالجة المركزية؟ حسنًا ، وحدة المعالجة المركزية هي عقول جهاز الكمبيوتر الخاص بك. إنه الشيء الموجود في جهاز الكمبيوتر الخاص بك الذي يقوم بكل العمل ، كل التفكير. الآن ما نوع التفكير الذي يحتاج الكمبيوتر إلى القيام به؟

Well, if you're feeding it all of these numbers, and you're feeding it all of these letters, you want to maybe perform math on those numbers. You might want to display those letters on the screen. You might want to add or delete those letters if the user is using a word processor and typing new characters or hitting delete. And so a computer needs to do all of that thinking and work for the human. And the peace inside of the computer that does most of that work is, indeed, this device here called the CPU. Now, it turns out, that CPUs today are actually getting pretty fancy. And inside of a CPU, typically, is one or more cores, so to speak. And a core is really what's doing the work. And it is the device inside of this device that actually can do addition, and subtraction, and multiplication, and division, and other operations still loading information from memory, saving information to memory. And so a CPU like this might have one, or two, or four or more cores, which means it can do one, or two, or four or more things at a time. And that's great because, these days on my Mac or my PC, I might double-click a whole bunch of icons. I might be running multiple programs. I might be chatting with a friend over here. I might be working on my homework over here. And so I might have a lot of programs and a lot of files open simultaneously.

حسنًا ،

إذا كنت تغذيها بكل هذه الأرقام ، وتغذيها بكل هذه الأحرف ، فربما تريد إجراء العمليات الحسابية على هذه الأرقام. قد ترغب في عرض هذه الأحرف على الشاشة. قد ترغب في إضافة هذه الأحرف أو حذفها إذا كان المستخدم يستخدم معالج كلمات ويكتب أحرفًا جديدة أو ينقر على حذف. ولذا يحتاج الكمبيوتر إلى القيام بكل هذا التفكير والعمل من أجل الإنسان. والهدوء داخل الكمبيوتر الذي يقوم بمعظم هذا العمل ، في الواقع ، هذا الجهاز يسمى هنا وحدة المعالجة المركزية. الآن ، اتضح أن وحدات المعالجة المركزية (CPU) اليوم أصبحت في الواقع خيالية جدًا. وداخل وحدة المعالجة المركزية ، عادة ، يوجد نواة واحدة أو أكثر ، إذا جاز التعبير. والجوهر هو حقًا ما يقوم بهذا العمل. والجهاز الموجود داخل هذا الجهاز هو الذي يمكنه فعلاً القيام بعمليات الجمع والطرح والضرب والقسمة ، ولا تزال العمليات الأخرى تقوم بتحميل المعلومات من الذاكرة ، وحفظ المعلومات في الذاكرة. وبالتالي ، قد تحتوي وحدة المعالجة المركزية مثل هذه على واحد أو اثنين أو أربعة مراكز أو أكثر ، مما يعني أنها يمكن أن تقوم بواحد أو اثنين أو أربعة أشياء أو أكثر في وقت واحد. وهذا رائع لأنه في هذه الأيام على جهاز Mac أو جهاز الكمبيوتر الخاص بي ، قد أقوم بالنقر نقرًا مزدوجًا فوق مجموعة كاملة من الرموز. قد أقوم بتشغيل برامج متعددة. قد أتحدث مع صديق هنا. ربما أعمل على واجبي المنزلي هنا. ولذا قد يكون لدي الكثير من البرامج والكثير من الملفات تفتح في وقت واحد.

And thanks to multiple cores inside of a CPU, can each of those programs continue running in parallel. Maybe one is printing something to my printer. Or maybe one is playing back a video. Maybe one is spell-checking a file. Any number of operations can literally be happening simultaneously. Now moreover, it turns out that the fanciest of use today, from Intel especially, also support something called hyperthreading, which means you might just have one CPU or one core, but thanks to some technology built into the CPU itself, it will present itself to the computer, to the operating system, Mac OS or Windows-- more on those in a bit-- as though it's actually two CPUs or two cores. And so, thanks to technology, can your computer actually think it has even more computational power than it actually has, thereby allowing it to take advantage of downtime or slow running programs that might still allow you to run multiple things simultaneously. But we'll come back to that in just a bit.

وبفضل النوى المتعددة داخل وحدة المعالجة المركزية ،

يمكن لكل من هذه البرامج الاستمرار في العمل بالتوازي. ربما يقوم أحدهم بطباعة شيء ما على طابعتي. أو ربما يقوم أحدهم بتشغيل مقطع فيديو. ربما يقوم أحدهم بالتدقيق الإملائي لملف. يمكن إجراء أي عدد من العمليات في وقت واحد. علاوة على ذلك ، اتضح الآن أن الاستخدام الأكثر روعة اليوم ، من Intel على وجه الخصوص ، يدعم أيضًا شيئًا يسمى hyperthreading ، مما يعني أنه قد يكون لديك وحدة معالجة مركزية واحدة أو نواة واحدة ، ولكن بفضل

بعض التقنيات المضمنة في وحدة المعالجة المركزية نفسها ، ستقدم نفسها إلى الكمبيوتر أو إلى نظام التشغيل أو Mac OS أو Windows - أكثر على أولئك الموجودين قليلاً - كما لو كانت في الواقع وحدتا CPU أو مركزان. وهكذا ، بفضل التكنولوجيا ، هل يمكن لجهاز الكمبيوتر الخاص بك أن يعتقد أنه يتمتع بقوة حسابية أكبر مما لديه بالفعل ، مما يسمح له بالاستفادة من فترات التوقف أو البرامج التي تعمل ببطء والتي قد لا تزال تسمح لك بتشغيل عدة أشياء في وقت واحد. لكننا سنعود إلى ذلك بعد قليل.

Now, not all devices have just a CPU connected to a motherboard. Some devices, instead, have a CPU and more all interconnected all at once. And these things are generally known as systems on a chip. And they're especially popular in things like tablets or iPads these days, game consoles like Xboxes or even things like the Raspberry Pi, which is a very small computer that looks pretty much like this. Also not to scale, this thing could fit in the palm of my hand. And this has, not only one of these silicon circuit boards-- generally green, and you'll see there's very fine lines or traces that interconnect all of the chips and technology that's plugged into this thing-- and it also has, well, first and foremost, no case. There's no pretty plastic case that protects all of these components. It really is just a raw piece of hardware that computer technophiles like to use to build their own machines and programs. But it has a whole bunch of ports-- as we'll return to in a bit-- a whole bunch of places you can connect other devices. But these systems on a chip all come together. And they do many things beyond just the CPU's task alone. But what else is inside of your computer? Well, the CPU is the brain. And the CPU on a system on a chip is thereto the brain. But there's other components necessary inside of a computer so we can do actual work. And one of those things is called memory or random access memory. And random access memory looks, physically, like this. This is a chip that you might slide into a little slot inside of your computer specifically on the so-called motherboard, again, a big greenish board into which all of your computer's components connect. And there's usually a little divot here, a little bump to make sure you put it in the right way-- instead this way, instead of, for instance, that way. And then on this green circuit board are all these various chips that actually store your data. Specifically, they store your data in a volatile way, only when the power is on, when your laptop has battery and is running or when your laptop is plugged in and is running. Which is to say, when you double-click an icon on the screen or run some program, open some file, those files are loaded into the little black chips that you see on this stick here. They're loaded into RAM or Random Access Memory. And this memory is pretty fast. And it is where those files and programs live, so long as you are using them at a given moment in time. Now other devices have slightly different looking sticks of RAM. This is a smaller stick here that's actually found, typically, in

laptops or certain desktop models, but it's the same idea. It's simply a different form factor. Now you can actually see in your Mac or PC sometimes exactly how much RAM you have, especially if you bought the computer without knowing this concept or were given the computer and didn't think to ask. In fact, on Windows, if you open up the so-called Task Manager and look at the CPU tab, you might see a little something like this. You'll see one, a nice little chart that shows you what your CPU has been doing over the past few seconds. And the higher these peaks are, the busier it was. Maybe you double-clicked an icon or played a video or sent a really big email or something like that. But more interesting, down here, is the speed of your CPU. This one is 1.9 for gigahertz. And a gigahertz means 1 billion things per second. So a you that's 1.9 for gigahertz means that this computer, this CPU can do 1.94 billion things per second-- additions, subtractions, multiplications, printing to the screen, any number of other things. But if we look, odds are this is marketed, frankly, as 2 gigahertz, and maybe it has burst technology whereby it can actually go even a little faster, maximum speed 2.81 gigahertz by maybe using a little more energy for some amount of time and therefore generating a bit more heat. But you'll see that there's only one socket in the computer from which I took this screenshot from Windows, which means there's one CPU. But that CPU has two cores, which means that the computer can do literally two things at once because it has really two brains inside of that device that we saw a picture of a moment ago. But logically, it actually seems four. So this particular windows computer has a CPU with two cores, each of which supports that technology called hyperthreading, which means that each of those cores will present itself to the Windows operating system as though it's two. Which is to say each core will do two things simultaneously, thereby giving me four logical processors or, really, the ability to do 4 total things at once. So perhaps lower level detail than is perhaps germane, but these are the kinds of things that you end up paying for in a store or when you buy a computer online. This is what distinguishes a less expensive computer from a more expensive computer is just how fast the CPU or CPUs are and just how many cores the CPU has and, therefore, just how much work you can get done at a given moment in time or just how quickly you can work more generally. Now, in a Mac, if you open up your System Profiler, you'll see a different kind of interface, but similar information. This is taken here from a MacBook Pro. You can see that this CPU is 3.1 gigahertz, so faster, but it has one processor, total number of cores is two. And so, here, we see no mention of hyperthreading, which generally windows is a bit more detailed on, but this does mean that this CPU is pretty darn fast, 3.1 billion things per second. And it actually has two cores, so it can do at least two things at once. All right. So that's my CPU, which does all the thinking and all of the work. That's RAM or random access memory where all of my data and programs are stored while I am using them. So what else do I need? Well, where are those programs and

files stored when the power is not on or when my battery is dead or when my computer is not even plugged in. Now, odds are, if your computer is like mine, you don't lose all of your files and all of your programs just because your battery dies or you move a computer, and therefore, unplug it from the wall. It would not be a very useful device. Computers do have nonvolatile memory that sticks around even when the power is lost, but it uses a different technology than RAM for that. It tends to use a disk or a hard disk, as in this case. So this is a device that a PC desktop or Mac desktop might have inside of it. And it actually stores quite a bit more information than a stick of RAM. A stick of RAM might store one gigabyte, two gigabytes, maybe even 16 gigabytes. But a hard drive, as this thing is called, will actually store 256 gigabytes, or maybe 1,000 gigabytes, AKA a terabyte or even two terabytes or four terabytes, which is an order of magnitude more than our sticks of RAM. Inside of this device, though, meanwhile is something that feels kind of old school. It's actually one or more metal platters that literally physically spin around mechanically. And on those platters is your data actually stored. So in RAM, there were no moving parts. There is no fan, there's no motor, there's nothing to move back and forth. It's entirely electronic. It's all electrons at the end of the day. But a hard drive is a mechanical device that actually has one or more of these platters spinning and spinning and spinning. And that's what allows the computer to access different areas of those platters. And, in fact, you'll see one or more of these little reading heads, not unlike old school phonograph or record players that actually move back and forth and read the data from that device. And what's nice about this device is that it's nonvolatile. It uses tiny, tiny magnetic particles, little specks of magnetic particles, that, if you orient them this way might represent a 1. If you orient them this way it might represent a 0-- so north to south pole, south to north pole if you remember some of your electronics. But all that is to say is there's tiny, tiny, tiny little particles on here, billions or more perhaps, that, depending on their orientation up or down, represent a 1 or 0. And if you have enough of those particles, you can represent bytes or megabytes or gigabytes or terabytes or more or anything in between. And so you have the ability to store data this way or this way, even when the power is off. The power is used just to read the data or to write or change the data. It doesn't need to stick around to persist the data. So in fact, why don't we take a look at what this motor looks like when actually running. This is a short video from the Slow Mo Guys, which gives us a sense of what the hard drive looks like when its lid is indeed removed like that there. [VIDEO PLAYBACK] [END VIDEO] DAVID J. MALAN: Fascinating. I know. Well, now let's actually take the hood off of an actual hard drive, albeit via animation, and actually see and hear what it is that's going on. And in this depiction here, you'll see that the magnetic particles ultimately are represented as red-blue, or blue-red particles, which represent precisely those magnetic

particles that represent your 0s and 1s. [VIDEO PLAYBACK] - The hard drive is where your PC stores most of its permanent data. To do that, the data travels from RAM along with software signals that tell the hard drive how to store that data. The hard drive circuits translate those signals into voltage fluctuations. These, in turn, control the hard drive's moving parts-- some of the few moving parts left in the modern computer. Some of the signals control a motor which spins metal-coated platters. Your data is actually stored on these platters. Other signals move the read-write heads to read or write data on the platters. This machinery is so precise that a human hair couldn't even pass between the heads and spinning platters. Yet, it all works at terrific speeds. [END VIDEO] DAVID J. MALAN: So where are those particles? Well, for that, we're going to have to zoom in even closer because they're not visible to the human eye. [VIDEO PLAYBACK] - Let's look at what we just saw in slow motion. When a brief pulse of electricity is sent to the read-write head, it flips on a tiny electromagnet for a fraction of a second. The magnet creates a field which changes the polarity of a tiny, tiny portion of the metal particles which coat each platter surface. A pattern series of these tiny charged up areas on the disk represents a single bit of data in the binary number system used by computers. Now, if the current is sent one way through the read-write head, the area is polarized in one direction. If the current is set in the opposite direction, the polarization is reversed. How do you get data off the hard disk? Just reverse the process. So it's the particles on the disk that get the current in the read-write head moving. Put together millions of these magnetized segments, and you've got a file. Now, the pieces of a single file may be scattered all over a drive's platters kind of like the mess of papers on your desk. So a special extra file keeps track of where everything is. Don't you wish you had something like that? [END VIDEO] DAVID J. MALAN: Now, anytime you have a physical device like this that's spinning all day long or for months on end, if you use your computer a lot and for quite a long period of time, something could go wrong. Maybe you accidentally bump the desktop or the laptop, the result of which is that this reading head might actually strike the platter and make a dent in it or some kind of scratch which actually will corrupt, not only some of the data perhaps, but might even stop the whole device from working if the reading head no longer functions properly. Moreover, anything that's physical like this isn't going to spin all that fast at the end of the day. Now technically, a hard drive like this might spin 7,200 times per minute or even 10,000 times per minute, but that's much, much slower than the speed with which electrons travel as they would in something like RAM. Well, fortunately, it turns out that there's something in between those technologies that doesn't have moving parts, but that's not quite as fast as RAM, but that is non-volatile, whereby it will store your data persistently even when the power is off. And this is so-called flash memory or a Solid State Disk, SSD, in this case here. It's a smaller device,

whereas typical hard drives that have moving parts are very often 3 and 1/2 inches, although 2 and 1/2 inch versions do exist as well, in diameter. A solid state drive tends to be only 2.5 inches in width so that it actually fits inside of computers in the same slots that older more mechanical hard drives might fit. But it doesn't have moving parts. In fact, if we open it up, you'll see something very reminiscent of the RAM we saw earlier. But the technology inside of this device is such that the data persists, even when your battery dies or you unplug your laptop or desktop. But the upside of an SSD, being entirely electronic, is that it's much faster. And so this means that your programs will load faster when you double-click them, your files will open up faster when you double-click on them. Anything you might do or save to your hard drive or solid state drive, in this case, will actually get saved much more quickly, which means you might see a little hourglass or spinning beachball much less frequently. And your computer is going to behave and certainly feel faster. Now the catch is that solid state drives, theoretically, won't necessarily last as long, depending on the quality of the brand and the technology being used whereby they only have a finite number of writes. You can read from them nearly as much as you want. But over time, they'll degrade in terms of how many times you can keep writing to them. Now, for many people this might be a non-issue, but to mitigate against this, has the industry also introduced what are called hybrid drives-- hard drives that might be the same size as this or the same size as a 3 and 1/2 inch drive like the spinning mechanical device we saw a moment ago in our animated form-- but they might have both some solid state memory and some mechanical hard drive memory so that you might have a few megabytes or gigabytes of solid state memory. And you might have a few gigabytes or terabytes of traditional hard disk space. And the device itself moves your data around in a clever way so that it tries to keep as much of the data that you want to use, at a given moment, on the solid state part of the device so that it's readily accessible for you. And the data that you might not need, right then and there, stays on the slower, more mechanical device where, nonetheless, you have a lot more storage. Now flash memory is something you might have heard about before now, but in the form of these things here, USB sticks that might store 1 gigabyte or 16 gigabytes or more. But it's data that you might want to carry around on your keychain or in your pocket or keep around on your desk simply for transferring files from one computer to another or keeping some data with you. They tend to be slower though, than solid state drives. They tend to be less reliable. But they also tend to be much less expensive, but also smaller in capacity. But the technology is very similar in spirit. If you need more storage space than that, you might actually carry around with you a solid state drive externally. So it might be a little bigger, and a little heavier, and not something you want to put on your keychain. But this might store 256 gigabytes of space or even a terabyte of space, all of which is now carried around externally. And via some kind of cable can

you plug this device into your laptop or desktop or maybe a friend or colleague's computer so that you can share files without having a local network. If you need even more storage than that, 1 terabyte, 2 terabytes, 4 terabytes, or more, you might actually have another type of external hard drive inside of which is one of those older more traditional mechanical drives, the 3 and 1/2 inch disk devices, that might store much, much, much more data. But the price you pay is that it's a mechanical device. It might be, therefore, a little bit slower. And so ultimately, there's this trade-off between how much space you get, how much money you're spending, and how quickly you can get data from and to that external device. In fact, there's this whole series of trade-offs that we've seen thus far. And you can actually think of these various types of memory inside of a computer like a funnel of sorts whereby you have a pretty big opening where you keep a lot of your data on the biggest of your devices. But the goal is to get that data closer and closer and closer to your computer's brain where it can do some actual work. Indeed, if you think of the CPU as being at the bottom of this funnel, that's to whom you want to get all of this data. So throughout this funnel, you might have your hard disk or your solid state disk up here which stores a lot of your files a lot of your programs persistently in a nonvolatile way so that it's permanent even when the power or battery no longer works. But that hard disk or solid state disk ultimately feeds information down to your computer's RAM. But the ram is not the last stop before the computer's CPU. It turns out that there's other types of memory that a computer has that you might even see mentioned on your computer screen. So if up here you have your disk, whether it's a hard disk drive or a solid state disk drive, you might have quite a bit of this. This might be in the order of gigabytes or terabytes, billions of bytes or trillions of bytes. That gets fed into, ultimately, your computer's RAM, which probably exists on the order of these days of gigabytes, but fewer gigabytes than your actual disk. Down here you're going to have your CPU. And indeed, the goal is to get your data to the CPU. And the CPU, of course, is measured not in bytes but in gigahertz-- the number of billions of things it can do per second with that data. But there's also tends to be something in between RAM and CPU. There's often something called Level 3 cache, which might exist in the form of megabytes worth. Then it goes into what's called Level 2 cache, which is another type of memory, which also might be in the kilobyte or thousands of bytes or megabyte range. And then there might be L1 cache, which doesn't quite fit on this on the screen. But that's OK. Because it hints at just how small of a physical device this is, which might be on the order of, say, kilobytes. So these values will vary. And they'll certainly change over time. And so what's the pattern, then, among these various types of memory leading to the CPU? Well, the disk, whether a hard disk or solid state disk, is not only nonvolatile-- sticks around permanently, and it's where your files and your programs are stored when the power is off-- that's

the biggest of these various types of memories, but it's also the slowest. Even solid state is slower than some of these other memories below it on the funnel here. Meanwhile, RAM tends to exist, still on the order of gigabytes, but maybe 1 gigabyte, 4 gigabytes, 16, maybe more if you've splurged on a really nice computer. But RAM recall is where programs and files live when you double-clicked or opened them in order to use them on your computer at a given moment. Meanwhile though-- and this is values you don't really control because they tend to be associated closely with the CPU or the motherboard that you've bought as part of your computer-- that RAM feeds information into Level 3 and/or Level 2 and/or Level 1 cache in turn so that it's less memory there, but it's super, super fast. And that ensures that, even though there's less of this memory-- Level 1 cache exists in smaller quantities than Level 3-- that funnel is just always filled. There's always something at the bottom of the funnel ready to be fed into the CPU. So the CPU never, theoretically, has to wait for any data-- to get numbers to crunch, or text to display, or the like. Meanwhile, there exists, turns out, tiny little pieces of memory in a computer that we'll give a name to called registers. And these registers typically only hold 1 byte or 4 bytes or 8 bytes total. So they're the smallest unit of memory. But it's in those registers that the CPU stores values like numbers like those decimal numbers we discussed earlier. And if it wants to perform arithmetic of any sort, it stores those values in these registers, actually performs the math, stores the result in another register, so it's, then, ready to be loaded back through this funnel into something like the computer's RAM or ultimately saved back to disk. But there's another trade-off here. Besides the top of this funnel being bigger and slower, and the bottom of this funnel being smaller and faster, the bottom of the funnel also tends to be more expensive, which also explains, in part, why you see less of this memory inside of a computer. The Level 1 cache might be more expensive than ram, so you have less of it and, technically, you don't even need as much of it so long as there's enough to keep data waiting for the CPU. But cost is certainly another trade-off as well. But the types of numbers that you, as a consumer, might care about, really, would be how big the disk in your computer is and how much data and programs and files you can store, how much RAM your computer has. Because that correlates with just how much work you can do at once, how many files and programs you can keep running simultaneously without having to quit any of them. And so cache, finally, which is more closely tied to the CPU and the motherboard in your computer and, therefore, isn't really a number you have as much control over as the consumer, just ensures that the data is actually ready. Now this might all sound fairly technical. But these caches, whether Level 3 or 2 or 1 are actually quite similar to techniques that we humans use in the real world, for instance, even at your local candy store. Here's my candy store, and I'm open for business. SPEAKER: Candy, please? DAVID J. MALAN: Let me get you some candy. [FOOTSTEPS] Thank you. Come

again. Now that was not very efficient to have to go all the way and back into the store room to get the candy. Much more efficient would be to keep it closer to me in a place that's faster to access much like a cache of candy right here on the counter. In fact, let me go ahead and ready that cash. [FOOTSTEPS] And now, with this cache of candy am I open for business again. SPEAKER: Candy, please? DAVID J. MALAN: Thank you. Come again. Now this is a small cache of candy, but it's fast. And, with it, can I provide my customers or really my CPU with information much more quickly. Now we can actually see the sizes of these caches in that same output that we saw earlier from Windows and Mac OS. For instance, if we look again at the Windows Task Manager and look down here, you can actually see that this particular laptop had L1 cache on the order of 128 kilobytes or thousands of bytes. It had 512 kilobytes of L2 cache, and 4 megabytes of L3 cache. Meanwhile, if we take a look at that same MacBook Pro from earlier, you'll see that it has 256 kilobytes of cache, 4 megabytes of L3 cache, doesn't happen to mention L1 cache, but odds are, it's indeed there on the CPU, just not reported by this program. Now what else is inside or really outside of a computer? In fact, let's start to take a look at things, perhaps, more familiar. Now these are just graphical depictions of connectors or sockets on the back of your computer into which you might have very well plugged in various devices. In fact, this collection of ports here are all related to monitors or displays. So a computer, like a desktop computer, tends not to come with a monitor built in. And if it does, indeed not, you might need to plug-in an external monitor using something like mini DisplayPort-- very commonly found on laptops, especially if you want to have, not just your primary laptop display, but a secondary, a bigger monitor on your desk-- DisplayPort, which is the same idea, but a larger connector that you might typically have on a desktop plugging into a monitor-- HDMI, which you might have, not only on your laptop or desktop, but possibly even on your TV at home because this is also the type of cable that you would use to plug a TV into some kind of set-top device in your living room. And then, lastly, VGA-- still on the list, even though it's super, super old and not nearly as featureful as these other technologies. But you'll very often find at universities like this and companies that have long had projectors installed in their rooms, this older technology, and so it, too, is still pretty common. Now, what else might we want to plug into a computer? Well, any number of devices as well-- in fact, if you've ever seen this symbol, that means you have a port on your computer, desktop or laptop, into which you can plug a whole range of devices. If you've ever needed to plug a printer into your computer, you might use the port label with this-- a scanner, a digital camera, any number of other peripheral devices might be connected to your computer by way of this device here. Even your mouse and your keyboard, if they're not already wireless, would be plugged in with this device here. And it might actually take any number of shapes, though thankfully, some of

these are more common than others. This is the universal serial bus-- where a bus as a term technologically that refers to some kind of medium along which data can travel, much like a bus travels down a street. So USB has a whole bunch of different connectors as depicted here. And the most common of which is just this rectangular one that, rather annoyingly, only 50% of the time do you, if you're like me, plug the cable in the right way because it can only go in one certain way. So you might have to flip it around. But on the other end of that cable might be another type, not USB A, but USB B, which is commonly used to plug into the back of scanners and printers and beyond. More recently, though, have companies like Apples and others started using using USB C-- a third type of connector that, thankfully, can go either top down or bottom up, thereby, not having to think as much when you want to plug in a device. But there's any number of other variants of these connectors commonly seen on cell phones, in fact, for chargers and data cables, all of which support USB. Now the USB standard, itself, has evolved over time. So the latest and greatest version of USB devices and connectors are actually much faster than some of the historically older devices and cables. And so it actually does matter what kind of cable you have and what device you have as to whether or not it will transfer data as fast as you might like. Now why is this important? Well, one of the devices you can connect to a computer, typically via USB cable, is something like an external hard drive. And even if you have a super fast external hard drive that is, say, an SSD underneath the hood, if you're using a slower older USB cable or technology, you might not, nonetheless, be able to transfer that data off a very fast device over a slow cable to your computer. So keeping an eye out for the latest versions of these technologies like USB can actually be quite important. But, of course, you might not need cables at all for certain devices. Of course, if you want to use Wi-Fi or wireless internet in your home, in the airport, in Starbucks, or elsewhere, your computer just needs to support Wi-Fi, which odds are, it very much does these days. And you might see a symbol somewhere in your computer like this depicting as much. But not everything operates over Wi-Fi. In fact, devices that you might want to plug into or connect to your computer without a cable would tend to use not Wi-Fi, but another wireless technology called Bluetooth that Windows computers and Macs alike support these days. So in fact, if you have a wireless keyboard at home or at work, or a wireless mouse, or if you have any number of other devices that, somehow, are wirelessly communicating with your computer, perhaps even your headphones these days, odds are, those are using a technology called Bluetooth, which have a limited range of just so many feeds. They don't afford you nearly as much distance as something like Wi-Fi does, but that's a good thing. Because generally, this technology is used to interconnect your personal devices to your personal computer and not really to others around you. So with all of these various devices inside of and, potentially, connected outside of my computer, what is it

that ensures that they can all intercommunicate? And what is it that ensures that all of this works? Well, at the end of the day it's the, so-called, operating system whether it's Mac OS or Windows, which is simply software, that either you or, more likely, some manufacturer pre-installed on the computer that you bought. And that software is installed on your hard drive or your solid state disk so that it's there persistently. And so that, even when you unwrap that shrink-wrapped box that has had no power for some time, the operating system is ready to go. And, indeed, when you hit the power button on your laptop or desktop, it's the operating system, ultimately, that is loaded into RAM from disk, and is what you ultimately see. In fact, it's the operating system that gives you, literally, the graphical windows that you see and the icons and the buttons that you can click. But more importantly, it's the operating system that knows how to talk to your keyboard and your mouse. It's your operating system that knows how to display information on the screen. It's your operating system that knows how to move things around in memory and disk and reading and writing all of that information. And that's all thanks to software that comes with an operating system called device drivers-- special software designed to talk to a certain model of printer, to a certain model of camera, or scanner, and the like. And, in fact, even when Windows or Mac OS or Linux or any other operating system doesn't recognize some device-- maybe because it didn't exist when Windows or Mac OS or Linux was installed on your computer-- well, you can very often download new software device drivers from the manufacturer's website of the manufacturer that made that new technology. And that can teach Windows and Mac OS and Linux and others to understand that new hardware. And so there is a future-proofing built into these operating systems because, at the end of the day, they're just software. And so it's this intersection of hardware and software that makes these computers just so powerful. Now, it's all fun and good to talk about hardware and see it depicted on the screen. But let's actually get our hands dirty here and actually enter into our own laboratory and take a look on the outside and inside of some actual computers. I'm here now with Dr. Colton Ogden for a look inside a couple of computers. COLTON OGDEN: Happy to be with you guys today. We have an IBM ThinkPad laptop here. Nobody really needs to use it anymore. So I figured we'd show you guys what a computer looks like on the outside before we start digging in on the inside. So you want to start off by maybe showing what some of these ports are here on the laptop? DAVID J. MALAN: Yeah. Sure. So here's one of those older ports. And, indeed, this is an older laptop. This is a so-called VGA port into which you would plug a cable to connect it, either to an external monitor, or more realistically, on a campus or in a workplace. It's like a projector so that other people can see. If you can believe it, this is an RJ11 jack for an old school modem or a phone cable. So that you could actually dial up to AOL. COLTON OGDEN: Old school. DAVID J.MALAN: Here's an RJ45 connector, which actually looks like this here, as

sort of a fat network cable. And that's what you would use to get online with wired internet. Here, we have a microphone jack, if you have an external mic, headphone jack if you want to listen to music at work, USB to connect any number of external devices. And oh. What's this one we've got over here? COLTON OGDEN: It looks like we've got a DVD port. You don't see these very often anymore. It's not going to work because the laptop is off. But we also have a couple of USB ports here on the side. And I think that's pretty much all we have on this guy. DAVID J. MALAN: Yeah. A DVD or CD drive is what's known as optical storage. And it really is just a piece of plastic, the CD or DVD, with some reflective material on it and little divots or pits that are created with a laser that gets, then, read with the laser so that you can actually write 0s and 1s by, essentially, having a smooth surface or little bumps. But it's increasingly falling into disuse as Flash Media of various sorts is being used instead. Well, why don't we not gut this, although, I do see it's power cable sitting here. So you'll notice that most laptops like this have power cables that one go into the wall, then some other proprietary or standard connector that goes into the laptop, and then a brick. Sometimes that gets a little bit warm. And what this brick is doing is it's actually converting the 120 volts or 240 volts coming out of your wall to far fewer volts that your laptop can actually tolerate. Shall we take a look at the desktop next? COLTON OGDEN: Yeah. Perfect. So let's go ahead and take a look at the internals of a computer with this guy here. So I'm going to go ahead and just take off the casing's lid here. DAVID J. MALAN: And this is an older PC-- COLTON OGDEN: Yes. DAVID J. MALAN: --desktop right? An older Windows PC. And so you find that Mac computers aren't so readily taken apart. In fact, that's one of the features of Apple computers is that they have far fewer user serviceable parts, but the price you pay, of course, is that you can't upgrade them or reconfigure them, often using magnets to. COLTON OGDEN: Indeed. DAVID J. MALAN: All right. So what do we have inside of here? COLTON OGDEN: OK. So we have, in here, a lot of the parts you were just talking about in your lecture. We have a CPU with its heat sink here, right in the middle. DAVID J. MALAN: That's a huge heat sink. And that does what? COLTON OGDEN: It dissipates heat. A CPU is very hot. It's oscillating very fast. And so the purpose of this is to, with all of these planes, disperse the heat equally and then get rid of it alongside the fan as well, which acts in tandem with it. DAVID J. MALAN: Yeah. It's a big fan, like you would have in the summertime. COLTON OGDEN: Oh, yeah. Definitely. DAVID J. MALAN: All right. And what about these green sticks? COLTON OGDEN: These green sticks, we only have one in this laptop. But this is actually a stick of RAM, so random access memory where computers' programs are stored as they're loaded. DAVID J. MALAN: OK. And that's connected to this bigger green sheet, which is-- COLTON OGDEN: This bigger green sheet is the motherboard. It's sort of like the central hub for all the parts working together with the computer. It acts as sort of a messaging interface for everything. DAVID J. MALAN: OK.

And now, doctor, can I take a look at that piece of RAM? Do you need it? COLTON OGDEN: Absolutely. No. Let's take it out of here. DAVID J. MALAN: All right. So that just snaps right out. COLTON OGDEN: Snaps right out. DAVID J. MALAN: Ah. So it looks pretty much like the image we had earlier with a bunch of black chips here, each of which store some number of megabytes or gigabytes probably. And then the little gold pin, so to speak, that could actually get plugged in. And they can only go a certain way. In fact, I've done this blindly before where I've accidentally plugged it in the wrong way, only to realize, it actually goes this way. And that's why this little divot here is asymmetric. COLTON OGDEN: Indeed. DAVID J. MALAN: I'm done with this, doctor. OK. We're not going to put that back in. And what's this big thing in the back of a PC? COLTON OGDEN: So this is the Power Supply or PSU. It essentially just powers everything up with electricity in the computer. DAVID J. MALAN: I see. And so if this is the extent to which you've actually played with the inside of your computer before-- this, of course, is the power cable. And this is actually a standardized plug that goes back into the device. You can actually use this or any number of other cables on your own computer. COLTON OGDEN: Indeed. DAVID J. MALAN: All right. So where is my data stored when not in RAM persistently? COLTON OGDEN: When not in RAM, you have, here, an external Hard Drive, an HDB, or an internal hard drive in this context. DAVID J. MALAN: OK. So this is older and bigger probably than something like an SSD? COLTON OGDEN: Yes. Older and larger, but probably stores less since this is an older computer. And it's connected to the motherboard using what's called the SATA cable, S-A-T-A, which hooks right into the motherboard. DAVID J. MALAN: Oh, yeah. Can we can we pull that out without that much damage here? COLTON OGDEN: Yeah. Absolutely. So it's a pretty small cable, it plugs right into the motherboard there. DAVID J. MALAN: Ah. OK. So it's got kind of a nice angled shape so that it only goes, in it would seem, one way. All right. And actually, it looks like a different type of cable is used for this older technology. We seem to have another DVD or CD drive up there? COLTON OGDEN: We do. We do. We have a DVD drive. And actually it does you SATA as well. DAVID J. MALAN: Oh, Yes. COLTON OGDEN: It plugs right in with the hard drives. DAVID J. MALAN: Oh. But it has a special power cable that drives that. COLTON OGDEN: Yep. Exactly. DAVID J. MALAN: --just like the hard drive does too. So actually, we have, in advance, taken apart and 3.5 inch mechanical hard drive that you previously had a whole bunch of screws on it and probably previously had a whole bunch of data on it. But now that we've exposed it to the air, and therefore all of the dust particles here in the theater, probably not going to be very reliable anymore. But what's really cool now is that we took off all but one of the screws so we can actually pull this off. And you can see what's been inside your own hard drive perhaps all this time. So this is, again, is 3 and 1/2 inches across, which is a standard size, at least, for these older larger mechanical drives. There's also a 2.5 inch version of this

commonly found in laptops or even higher-end desktops these days. And there's that mechanical arm that won't move now because there's no power going into this. But if there were, we'd be plugging it in to the back of the device here and then that SATA cable, which actually runs the power. And how many-- it looks like there's two platters here. Two platters. So the data store probably on the top, on the bottom, and then on the other top, and the other bottom, thereby fitting even more data in here. And if this were an even newer bigger hard drive, we could probably fit even more platters, and therefore more data. And increasingly, is the data being stored closer and closer together, so all those magnetic particles are packed ever more densely, which also means we can store more bits and thus bytes and thus files and programs. All right. So what we also have here a motherboard. Can we take a closer look at this outside of the box? COLTON OGDEN: Yes. DAVID J. MALAN: So this one looks a little bit different. And, in fact, I don't see a CPU. Where's our CPU gone? COLTON OGDEN: Well, this one does not have a CPU. It's been taken out in advance. But most of the other components are still in place here. We have RAM, we have a heat sink, and we have a lot of other ports and such that we've seen on the other motherboard and was looking. DAVID J. MALAN: And these internal ports, what gets plugged into those? COLTON OGDEN: So these are PCI slots. You'll see oftentimes graphics cards, sound cards-- other things that aren't necessarily always with a computer, but are optional-- those get plugged into these ports here. DAVID J. MALAN: And it looks like if we plug this into the back of a computer just right, these things should stick out the back of the plastic case? COLTON OGDEN: Yes. These are ports that are often user-facing, so you can plug-in peripherals such as keyboards, mice, monitors with VGA ports, maybe headphones or speakers with these ports here, headphones, microphones line out, and a few other ports, maybe-- DAVID J. MALAN: Do you want to talk to them in some of these older ports? These are really from my day. So the parallel port, which is where we used to put our printers or serial ports-- I don't know what voice that is-- but our serial ports where we used to put our joysticks for playing the games, a VGA port, of course, and then a whole bunch of USB ports there, which we can actually take a closer look at a cable. So here's a common end of a USB cable. This is Type A, and so that's probably the most common type. But the white plastic on the inside suggests that this is an older cable. If you look at newer cables, you'll actually see that the inside is blue, which means its USB 3.0, which generally means faster, which means you can move data back and forth all the more quickly. But on the other ends of these USB cables-- you see, like the Type B connector here-- this is commonly found in the back of a printer or a scanner. So it's a slightly different plug. It keeps one end straight from the other. But you will actually see sometimes smaller cables like this one here, mini or micro USB, commonly found on phones or just smaller devices where it would be annoying to try to plug-in something as big as this. Well, I

think we have just a couple of other things here. Here we have-- this came from a computer. No CPU attached, but this is one of those heat sinks? You were talking about? COLTON OGDEN: It is. It's a combo of a heat sink and a fan for a CPU. DAVID J. MALAN: I see. So Intel Inside might also mean you have an Intel fan, it would seem, and heat sink. And then lastly, we've got one of these things here. What's this here? COLTON OGDEN: This is a solid state hard drive, which actually uses flash memory very akin to microSDs, if you're familiar. It's essentially what a hard drive is. But instead of having a movable mechanical arm that looks at the different bits on the platters, as we talked about, it's almost like RAM. It's just storing the data in electricity, hence solid state, no moving parts. DAVID J. MALAN: But permanently. COLTON OGDEN: But yes. It's nonvolatile, which means, unlike RAM, you can actually store this whether or not you turn your laptop off or whatever. DAVID J. MALAN: All right. And it looks like-- and I'm told I've got to be extra careful with this-- this is a 4 terabyte SSD. So this is a huge amount of data, 4 trillion bytes. So we're just going to put this safely over here. Less expensively, though, we have this little USB stick. It's still 128 gigabytes, but it's a little gimmicky. But this thing slides out here, and then you can plug it into your laptop or desktop or really any device. And it's a really convenient way, ultimately, just like moving files back and forth between each other. All right. Well, Dr. Ogden, thank you so much. I'm sure you're going to want to take care of putting this all back together. And this was hardware.