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<th><strong>Title</strong></th>
<th>Alan Turing: Thinking the Unthinkable, Solving the Unsolvable</th>
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<tr>
<td><strong>Name(s):</strong></td>
<td>Dylan de Leon, Caleb Li, Raymond Li</td>
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<td><strong>Division:</strong> (Junior/Senior)</td>
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<td><strong>(Optional) Link to Any Audio or Video on Exhibit (no more than 3 minutes total):</strong></td>
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Germany’s success during World War II profoundly stemmed from their seemingly unbreakable ENIGMA code, prompting Alan Turing’s futuristic innovations in computer and mechanical development. His ideas led to the Bombe, an electro-mechanical device which deciphered machines like ENIGMA accurately and efficiently. Turing’s works tested the limits of technology and broke barriers in theoretical computer science by redefining the capabilities of computers and laying the groundwork for artificial intelligence.
ALAN TURING
Thinking the Unthinkable
Solving the Unsolvable
Picture of Left Panel of Exhibit
“The Analytical Engine has no pretensions whatever to originate anything. It can do whatever we know how to order it to perform. It can follow analysis; but it has no power of anticipating any analytical relations or truths. Its province is to assist us to making available what we are already acquainted with.”

–Ada Lovelace, Creator of the Analytical Engine

“Babbage’s computer used vast banks of rotating drums. The design was truly unprecedented and visionary, allowing it to store 1,000 numbers, each stretching to 40 decimal digits. Just like a modern computer, it incorporated a separate processor and memory bank, looping, and conditional branching. It even had a printer.” Although the engine would have been considered the first general-purpose computer due to its incorporation of arithmetic logic units and integrated memory, “Babbage only had funding to assemble a few parts.”

–Dominic Selwood, English Historian and Journalist

“The description that [Alan Turing] gave of a “universal” computing machine was entirely theoretical in purpose, but Turing’s strong interest in all kinds of practical experiment made him even then interested in the possibility of actually constructing a machine on these lines.” Despite Turing’s universal computer being an extraordinary intangible device that could potentially execute any given algorithmic task, “[Turing] didn’t confine himself to merely thinking about this possibility.”

–Martin Davis, The Universal Computer: The Road from Leibniz to Turing

“Gödel’s 1931 work left open the question of the decidability of mathematical propositions, and this is what Turing set out to answer. The particular technique of Gödel numbering was also influential in Turing’s 1936 work. Gödel had shown how to encode theorems about numbers, as numbers. Turing went on to show how to encode operations on numbers, by numbers.”

–Andrew Hodges, Alan Turing Historian and Biographer
“The [Enigma] consists of a box with 26 keys labelled with the letters of the alphabet and 26 bulbs which shine through stencils on which letters are marked […] When a key is depressed the wheels are made to move in a certain way and a current flows through the wheels to one of the bulbs. The letter which appears over the bulb is the result of enciphering the letter on the depressed key with the wheels in the position they have when the bulb lights.”

–Alan Turing, Treatise on the Enigma

The ENIGMA machine was an encryption device used to protect military communication by encoding strategic messages. Created by Arthur Scherbius, the machine was adopted by all branches of the German military in 1926, and modified by the Luftwaffe military in 1944. The device was considered uncrackable due to having nearly 159 quintillion possible combinations.

“The most important use of the Enigma was on the German U-boats…Every submarine had one. During the war, submarines were deadly. They sank 3,000 ships and killed 150,000 men. Fifteen million tons of cargo went down. They were really threatening to win World War II. It was critical to decipher the Enigma messages.”

–Tom Perera, Ph.D, Founder of The Enigma Museum

“If we are trying to produce an intelligence machine and are following the human model as closely as we can we should begin with very little capacity to carry out elaborate operations or to react in a disciplined manner to orders (taking the form of interference). Then by applying appropriate interference, mimicking education, we should hope to modify the machine until it could be relied on to produce definite reactions to certain commands. This would be the beginning of the process. I will not attempt to follow it further now.”

–Brian Jack Copeland, Intelligent Machinery
Germany's success during World War II profoundly stemmed from their seemingly unbreakable ENIGMA code, prompting Alan Turing's futuristic innovations in computer and mechanical development. His ideas led to the Bombe, an electro-mechanical device which deciphered machines like ENIGMA accurately and efficiently. Turing's works tested the limits of technology and broke barriers in theoretical computer science by redefining the capabilities of computers and laying the groundwork for artificial intelligence.
“The Turing machine concept involves specifying a very restricted set of logical operations, but Turing showed how other more complex mathematical procedures could be built out of these atomic components.”

–Andrew Hodges, Alan Turing Historian and Biographer

Eventually, Turing’s Bombe machine worked, descrambling the ENIGMA messages and allowing Allied forces to protect themselves from German strategies.

Turing was intrigued by the possibility of machines with intelligent minds like that of a human, except with more precision and efficiency. This theory broke barriers in computer science by conceptualizing the idea of learning machines, thus creating the basis of what would evolve into the technological age of artificial intelligence.

“In order to break the message we must try various assumed texts (cribs) derived from experience with the habits of the German operators and the type of traffic handled over the intercepted messages. It is known from call signs and direction finding what organizations (ground forces, air forces or navy) originate the messages and from what locality.”

–Alan Turing, in his report explaining the process for cracking ENIGMA codes

“In 1945, the war over, Turing was recruited to the National Physical Laboratory (NPL) in London to create an electronic computer. His design for the Automatic Computing Engine (ACE) was the first complete specification of an electronic stored-program-all-purpose digital computer. Had Turing’s ACE been built as he planned, it would have had vastly more memory than any of the other early computers, as well as being faster. However, his colleagues at NPL thought the engineering too difficult to attempt, and a much smaller machine was built, the Pilot Model ACE (1950)...[Alan Turing’s] earlier theoretical concept of a universal Turing machine had been a fundamental influence on the Manchester computer project from the beginning.”

–Brian Jack Copeland, britannica.com
Timeline

**Before Turing**

- Punch cards, 1890
- Assembly line with minimal manual assistance, 1913

**Turing Influenced**

- Turing Machine, 1936
- Bombe machine, 1940
- ENIAC, 1946
- Replica of Konrad Zuse’s Z3, 1941
- EDVAC and its creator John Von Neumann, 1946
- Pilot ACE, 1950
- IBM 5100, 1974
- Epson HX-20, 1982
- Motorola DynaTAC 8000X, 1983
- IBM Simon Personal Communicator, 1994
- Kismet, a robot with rudimentary social skills, late 1990s
“Early in the war, in 1939, he had broken the Enigma used by the Luftwaffe and the German army, but he’d been unable to break the naval Enigma. In 1940/41 the German U-boats were sinking our food ships and our ships bringing in armaments left right and centre, and there was nothing to stop this until Turing managed to break naval Enigma, as used by the U-boats. We then knew where the U-boats were positioned in the Atlantic and our convoys could avoid them. If that hadn’t happened, it is entirely possible, even probable, that Britain would have been starved and would have lost the war.”

–Captain Jerry Roberts, colleague of Alan Turing

“The intelligence which has been emanated from you before and during the campaign has been of priceless value to me. It has simplified my task as a commander enormously. It has saved thousands of British and American lives and, in no small way, has contributed to the speed with which the enemy was routed and eventually forced to surrender.”

–General Dwight Eisenhower, Former President/Supreme Allied Commander of Allies

Turing’s deciphering of ENIGMA greatly benefited the Allies and continued to give them the upper hand in the war.

“Until the end of the war, for another four years, the allies had an incredible advantage, which, ultimately, won the war. Historians estimate that breaking enigma shortened the war by two years, saving over 14 million lives.”

–Niklas Goke, Writer

“The Nazis didn’t just take battle plans and explosives into World War II; they had plans for a whole new world order. When the fighting and the bloodshed were done, they were going to build a new fascist empire over the ruins of Europe. The Nazis already had written up the blueprints for their new order. If everything had gone according to Hitler’s plan, the world today would be a different place.”

–Mark Oliver, Author

Decrypting codes were just as important as fighting out on the front lines because armies relied on the tactical information that was analyzed by the codebreakers. Having control over communication, one of the most decisive aspects of warfare, gave the Allies an upper hand.
“Since its inauguration in 1966, the ACM A. M. Turing Award has recognized major contributions of lasting importance in computing. Through the years, it has become the most prestigious technical award in the field, often referred to as the ‘Nobel Prize of computing.’”

–ACM.org (official website of Turing Award)

“Alan Turing was a pioneer in bringing AI from the realm of philosophical prediction to reality. He realized in the 1950s it would need greater understanding of human intelligence before we could hope to build machines which would ‘think’ like us.”

–Bernard Marr, Author

Many people thought Turing’s ideas would never come to fruition because the idea was so ahead of its time and the knowledge of machine functions were extremely limited. However, Turing has created an essential part of the world today. Completing tasks are much more efficient and effective with the aid of modern technology, a great benefit that wouldn’t exist without Turing’s contributions.
Conclusion

“Sometimes it is the people no one can imagine anything of who do the things no one can imagine.”

–Alan Turing

Alan Turing’s revolutionary ideas about intelligent machines broke barriers in analytical computer thinking and provided the foundations of artificial intelligence. Although his reputation was overshadowed by his homosexuality, his efforts continue to inspire a new generation of computer developers in making breakthrough discoveries to the field of computer science. Turing’s theories on logical machines have certainly impacted our world positively, redefining technology and paving the way for many more innovations to come.
Picture & Explanation of Interactive Elements on Your Exhibit

(You can include images and descriptions of parts of your exhibit that invite the viewer to engage with the exhibit beyond reading the text or looking at an image. Delete this slide if you don’t have interactive elements on your exhibit.)

https://youtu.be/CspaXNkC2ec
Picture of the Bombe