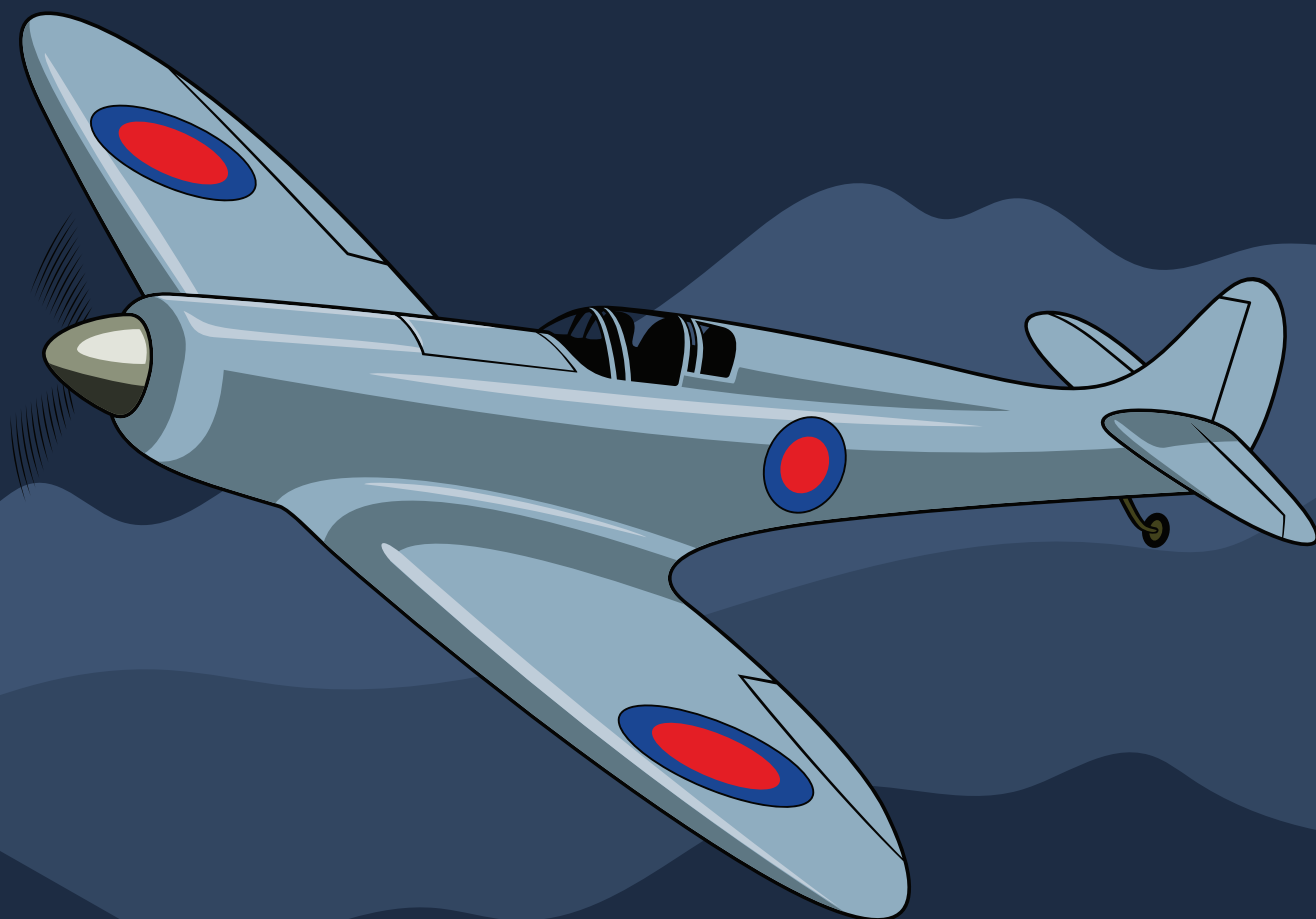


MATHS & CODING

ACTIVITY WORKPACK 5



 **ROYAL
AIR FORCE**
Youth STEM

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ABOUT THESE MATERIALS

This resource pack provides students with the opportunity to explore the science and history underpinning the development and deployment of Spitfire AA810 during WWII. The materials form part of a suite of five resource packs exploring a particular area linked to Spitfire AA810. These resources concentrate on **maths and coding**. Curriculum links for KS3 learners are provided below to support embedding the content within your structured delivery or teaching sessions.

CURRICULUM LINKS



History / STEM

- ✓ **Science in Society:** Exploring the historical significance of scientific and mathematical advancements in World War II, particularly how coding and decryption technologies helped win the war.

Mathematics

- ✓ **Logical reasoning:** Applying logical reasoning and critical thinking to solve encryption puzzles and decode messages using frequency analysis and cipher wheels.
- ✓ **Mathematical problem solving:** Understanding and applying substitution ciphers like Caesar shifts, which can be linked to pattern recognition and problem-solving in cryptography..

Computer science

- ✓ **Algorithms and coding:** Applying logical reasoning and critical thinking to solve encryption puzzles and decode messages using frequency analysis and cipher wheels.

ABOUT SPITFIRE AA810



Spitfire AA810 is a famous aircraft from the Second World War. It is known for its important role in taking photographs of enemy areas. This particular Spitfire was used by a special group that flew deep into enemy territory to gather information through aerial photography. Unlike regular Spitfires, AA810 had no guns but instead carried lots of extra fuel and cameras. This allowed it to fly 2,000 miles to complete some of its missions. Today, there is a project to restore Spitfire AA810 so it can fly again. This project helps remember the brave pilots who flew it and it teaches people about their contributions during the war. You can find out all about this by [clicking here](#).

GUIDANCE NOTES AND ANSWERS

This pack has been designed so that it can be comfortably delivered in a 1-hour facilitated session with secondary pupils. This pack forms part of a series of resources designed to explore the history and science linked to Spitfire AA810 aircraft. Each pack in the series contains weblinks and QR codes to suitable background and contextual information to inform your delivery of the content. Answers to tasks and activities, where relevant, are provided below:

PAGE 8 & 9: Using cypher wheels: Break the code!

1. Spitfire
2. Ada Lovelace. The first female computer programmer.
3. The Bombe. Electromechanical device used to detect the Enigma's settings, which allowed the German codes to be decrypted.

PAGE 10: Cypher wheels: The ceasar shift

What would 'Alan Turing' become if you encrypted using a Caesar shift method, where each letter is substituted with the letter two places along in the alphabet? Yjyl Rspgle.

PAGE 13 & 14: Cypher Wheels: Codes and frequency

1. WKHHQJLPD. The Enigma (Caesar shift 3, a=d).
2. FUBSWRJUDSKB. Cryptography (Caesar shift 3, a=d).
3. FLSKHUWHAW. Cyphertext (Caesar shift 3, a=d).
4. URWRU (Pay attention to repeating letters, you don't have to work out every letter separately!) Rotor (Caesar shift 3, a=d).
5. MIRDYLXOA. Plugboard (Caesar shift 3, a=d).
6. PQBDXKLDXMEV. Stenography (Caesar shift 3, a=d). Steganography is the practice of concealing information within another message or physical object to avoid detection.

GUIDANCE NOTES AND ANSWERS

PAGE 16 & 17: Quiz: Code-breaking

- 1. What was the name of the German military encryption machine that was famously cracked by Allied codebreakers during WWII?**
(B) Enigma Machine.
- 2. Who is widely credited with leading the effort to crack the Enigma code at Bletchley Park?**
(B) Alan Turing
- 3. Which Allied country played a critical role in breaking Japanese naval codes during the Pacific War?**
(A) The United States.
- 4. What was the name of the operation that involved the breaking of German High Command communications through the Lorenz cipher?**
(A) Operation Ultra.
- 5. What was the name of the British code-breaking center where many important wartime ciphers were deciphered?**
(C) Bletchley Park
- 6. Which early mechanical computer was developed by Alan Turing and his team to help crack the Enigma code?**
(B) Bombe.
- 7. Which Allied operation successfully intercepted and decoded messages that led to the destruction of the German battleship Bismarck?**
(C) Operation Ultra
- 8. What key contribution did Polish cryptographers make to the effort to break the Enigma code?**
(B) They shared their research on Enigma with the British before WWII.

BLETCHLEY PARK AND THE ENIGMA MACHINE

During World War Two, a team of brilliant mathematicians and intelligence experts worked tirelessly at Bletchley Park to crack secret German codes. Among them was the renowned Alan Turing. They focused on deciphering the Enigma Code, a complex cipher used by the Germans for secure communication. Using early developing computers and innovative techniques, these codebreakers were able to unlock vital information, revealing German plans and communications ranging from battlefield strategies to diplomatic messages.

Their efforts not only showcased the power of collaboration and critical thinking but also played a crucial role in the Allied victory. With this activity, you will step into the shoes of these wartime codebreakers, learning about the methods that were used to outsmart the enemy.

THE ENIGMA MACHINE WAS A TOOL USED BY THE GERMAN ARMED FORCES IN WORLD WAR TWO. THE MACHINE WORKED LIKE THIS:



- A keyboard was used to type a message into.
- A plugboard scrambled the current, swapping pairs of letters.
- Rotors with 26 positions, one for each letter of the alphabet, scrambled the letters being typed.
- A reflector sends back electrical signals to further scramble the message.
- A lampboard displays the final encoded / decoded letters by lighting up.

THE ENIGMA MACHINE: HOW IT WORKED

The process of letter scrambling moved through the machine to ensure a completely scrambled code.



The settings on the machine were shifted everyday by operators, changing the rotor settings, positions and plugboard connections. The team at Bletchley Park had to compete with the complexity and ever changing nature of the codes, which they were able to achieve through early computers to crack the Enigma. This success was a significant event that contributed to the Allied victory of World War Two.

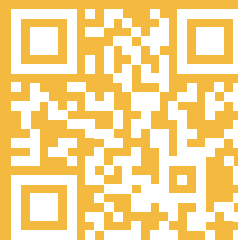


BLETCHLEY PARK



ENIGMA MACHINE

Scan the QR code or [click here](#) to explore a 3D model of the engima machine

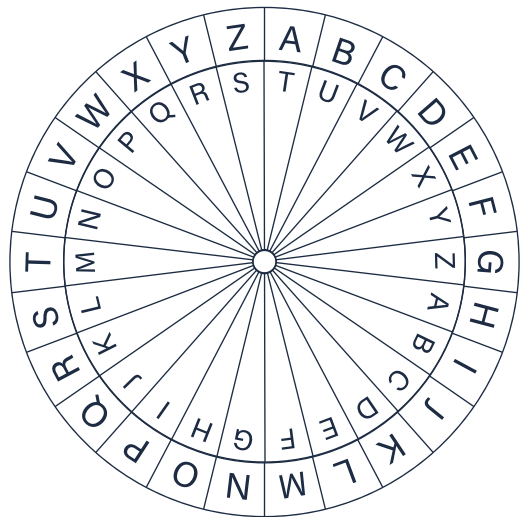


USING CYPHER WHEELS: BREAK THE CODE!

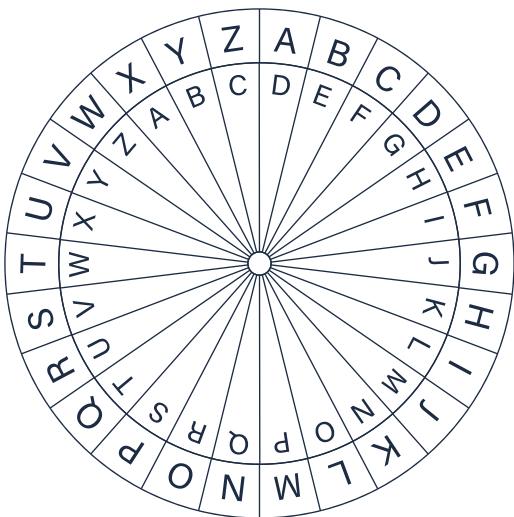


On the next page are messages that you need to decode using the three cypher wheels here. These represent Enigma's plugboard and rotors to which were successfully used to decrypt secret messages during WWII.

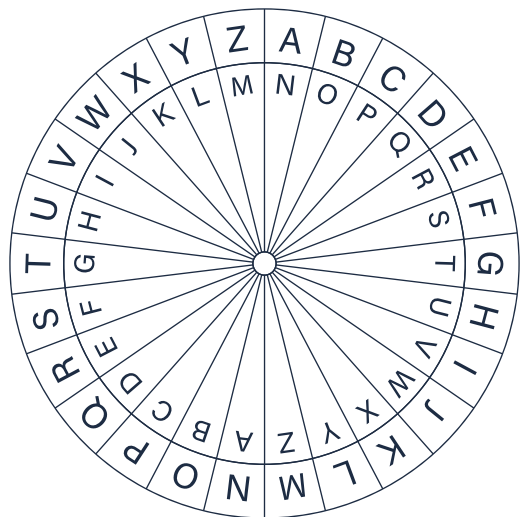
CYPHER WHEEL 1



CYPHER WHEEL 2



CYPHER WHEEL 3



To decode the following messages you must use each cypher wheel in turn. Read the first letter in the coded word on the outer ring of the 1st cypher wheel. Take the corresponding letter on the inner ring and then use this letter as the starting point on the 2nd cypher wheel (by looking for this letter on the outer ring of the cypher wheel). Carry out the same process for each cypher wheel until you have worked through all three. The final letter you arrive at is the coded letter.

ENCODED MESSAGES

1. JGZKWZYL

2. RUR CFMVCRTV

HINT: The first female computer programmer

3. KYV SFDSV

HINT: Electromechanical device used to detect the Enigma's settings, which allowed the German codes to be decrypted.

CYPHER WHEELS: THE CAESAR SHIFT

Another way to encrypt a message is to use a substitution cypher, which replaces one letter with another. There are many ways that you can use this cypher, but the easiest is substituting for the next letter in the alphabet. This is called Caesar Shift method. For example, 'a' becomes 'b', 'b' becomes 'c' and so on.

What would 'Alan Turing' become if you encrypted using a Caesar shift method, where each letter is substituted with the letter two places along in the alphabet?

This method is a little more time consuming than using standard cypher wheels but it is still a possible method for decoding messages. In the next activity, you will be provided with a blank cypher wheel to create your own code.

DID YOU KNOW?



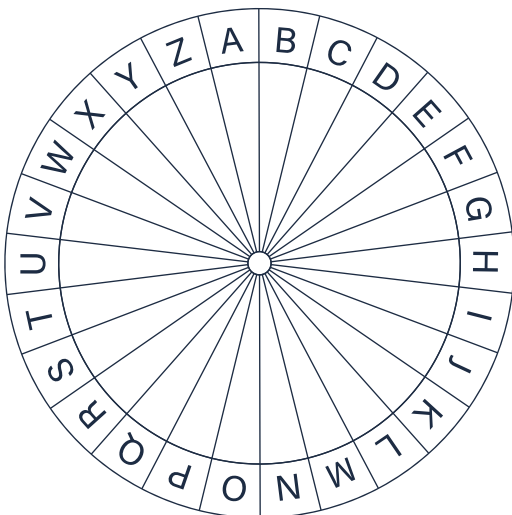
The Caesar cipher (also known as Caesar shift, Caesar's code, or shift cipher) is one of the simplest and most well-known encryption techniques. It is named after Julius Caesar, who is said to have used this cipher to communicate with his generals during wartime.



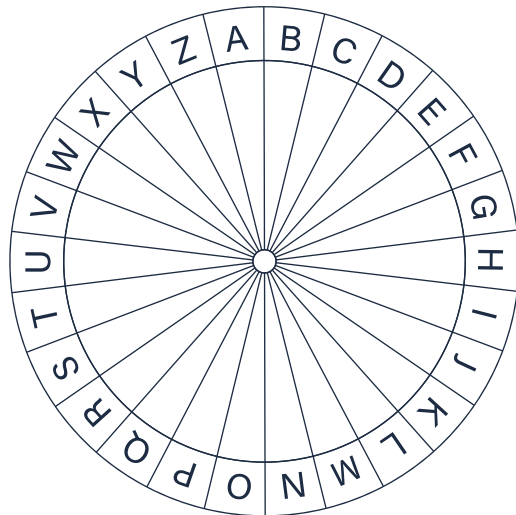
CYPHER WHEELS: CREATE YOUR OWN

1. Fill the cypher wheels with different Caesar Shift configurations of the alphabet to create your own code decryptor.
2. What is the Caesar Shift number for your wheel?
3. Use the cypher wheel to create a code of your full name.
4. Think of a code sentence to give to a friend along with your cypher wheel.
5. You will be testing their abilities to crack German codes.

CYPHER WHEEL 1



CYPHER WHEEL 2



CYPHER WHEELS: CODES AND FREQUENCY

The Bletchley Park team used an understanding of statistics along with early computer machines to decode German messages in WWII. In this activity, we will use an understanding of statistics to decode some simple messages. In the English language, the letters E, T and A are the most frequently appearing. The following frequency chart shows the most and fewest frequently appearing letters in the English language.

LETTER	FREQUENCY
E	12.7%
T	9.1%
A	8.2%
O	7.5%
I	7.0%
Q	0.2%
Z	0.1%
X	0.1%
J	0.2%

Statistical analysis is important in real-world codebreaking.

If we know that E is the most commonly appearing letter in the English language, which letter can we assume is the encrypted 'E' in the following code?

Knowing which letter is coded for E, what can we guess is the Caesar Shift number for this code?

Using the correct Caesar Shift, can you work out the full code?

ENCODED MESSAGES

1. WKHHQJLPD

On the following page are a number of codes. If you use the same method, can you break the code? To help you, cut out the two cypher wheels on page 15 to create your own Caesar Shift device. Use the inner ring of letters to determine which caesar shift has been used.



Scan the QR or [click here](#) to find out more about code breaking during WWII.



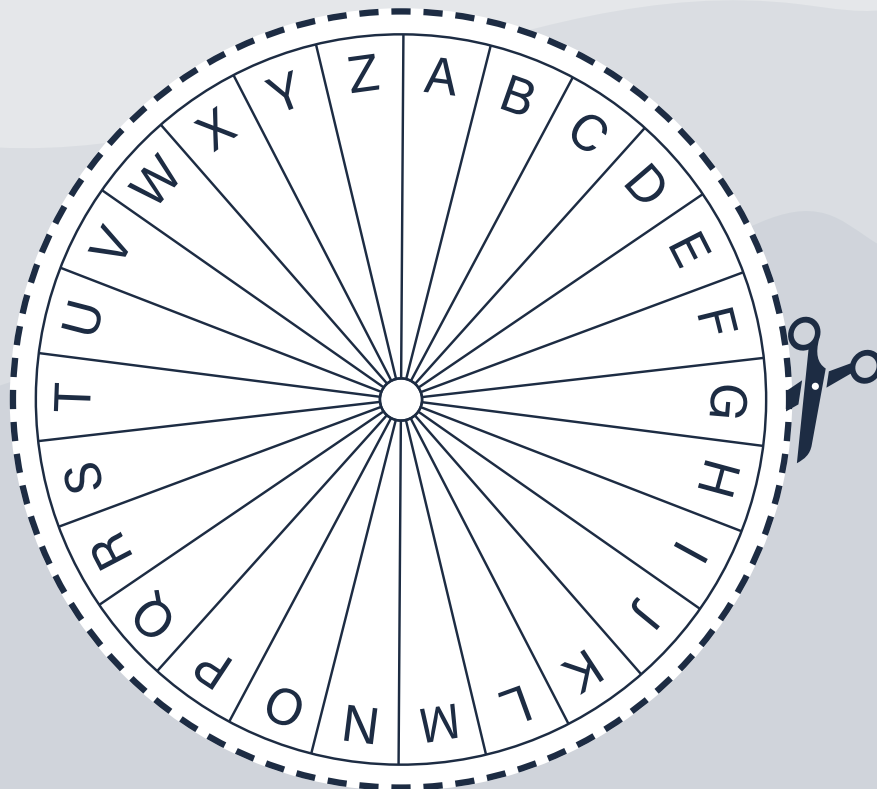
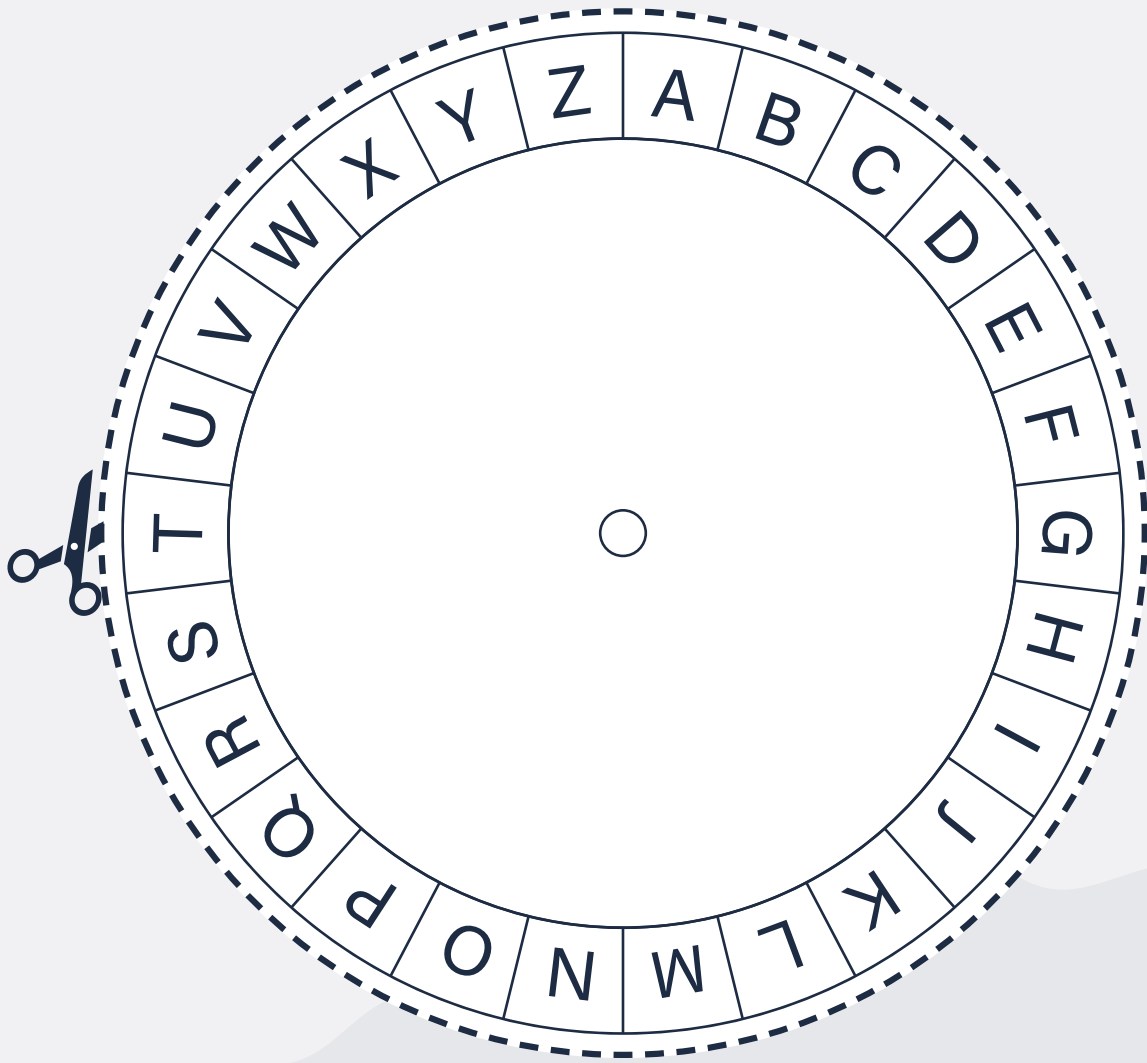
2. FUBSWRJUDSKB

3. FLSKHUWHAW

4. URWRU (Pay attention to repeating letters, you don't have to work out every letter separately!)

5. SOXJERUDG

6. VWHJDQRJUDSBK



QUIZ: CODE-BREAKING



Test your knowledge of code-breaking by taking our quiz. You might need to carry out some additional research to answer all of the questions. Good luck!

1. What was the name of the German military encryption machine that was famously cracked by Allied codebreakers during WWII?

- A) Lorenz Cipher
- B) Enigma Machine
- C) Bombe Machine
- D) Turing Machine

2. Who is widely credited with leading the effort to crack the Enigma code at Bletchley Park?

- A) Winston Churchill
- B) Alan Turing
- C) John von Neumann
- D) Franklin D. Roosevelt

3. Which Allied country played a critical role in breaking Japanese naval codes during the Pacific War?

- A) The United States
- B) The United Kingdom
- C) Canada
- D) Australia

4. What was the name of the operation that involved the breaking of German High Command communications through the Lorenz cipher?

- A) Operation Ultra
- B) Operation Sealion
- C) Operation Overlord
- D) Operation Hydra

5. What was the name of the British code-breaking center where many important wartime ciphers were deciphered?

- A) GCHQ
- B) MI5 Headquarters
- C) Bletchley Park
- D) Churchill's War Rooms

6. Which early mechanical computer was developed by Alan Turing and his team to help crack the Enigma code?

- A) Colossus
- B) Bombe
- C) ENIAC
- D) Univac

7. Which Allied operation successfully intercepted and decoded messages that led to the destruction of the German battleship Bismarck?

- A) Operation Magic
- B) Operation Torch
- C) Operation Ultra
- D) Operation Kraken

8. What key contribution did Polish cryptographers make to the effort to break the Enigma code?

- A) They developed the first electromechanical decryption machine.
- B) They shared their research on Enigma with the British before WWII.
- C) They infiltrated German communications.
- D) They created the Navajo Code Talkers.