Substitution Codebreaker

Alan Turing (1912-1954) was a British mathematician who made major contributions to maths, computer science and artificial intelligence. He introduced the theory for a computing device called a Turing machine. The Turing machine became the basis for all digital computers!

During the Second World War, he worked for the British Government. Turing and others designed a code-breaking machine called the Bombe. The Bombe was used to help decipher secret messages Germany used to communicate. They were able to learn about German military secrets and by early 1942, they were decoding about 39 000 messages a month!

In 1952, Turing was found guilty of being homosexual, which was a crime in Britain at the time. As a result, Turing had a criminal record, so he could no longer work for the government's code-breaking centre, and he was forced to take chemicals to try to change his sexuality. This is completely unethical by today's standards, and the government has since officially apologised and pardoned him:

'Thousands of people have since come together to demand justice for Alan Turing and recognition of the appalling way he was treated. While Turing was dealt with under the law of the time and we can't put the clock back, his treatment was of course utterly unfair, and I am pleased to have the chance to say how deeply sorry I and we all are for what happened to him ... So, on behalf of the British government, and all those who live freely thanks to Alan's work I am very proud to say: we're sorry, you deserved so much better.'

– Part of UK Government apology to Alan Turing, September 2009.

Task

A quote by Alan Turing has been put into a code. The table below shows how to decode each number to its corresponding letter.

Key

1	2	3	4	5	6	7	8	9	10
A	B	C	D	E	F	G	H	I	J

11	12	13	14	15	16	17	18	19	20
K	L	M	N	O	P	Q	R	S	T

21	22	23	24	25	26
U	V	W	X	Y	Z

You are also given the following information:

Algebraic Values

Letter in Expression	Value
a	5
b	8
c	1
d	6
x	-3
y	-2
z	4

Using substitution, find the values of each expression. Then, use the table to decode each answer to write out a quote by Alan Turing.

For example, for the question $a + b$:

Check the **algebraic values** table for the values of a and b.

Substitute into the expression:

$a + b = 5 + 8 = 13$

Check the **key** for which letter is encoded by **13**.

$a + b$, or 13, decodes as M

$az - c$	$a(z - c)$	$b + a$	ac	az	x^2	$x^2 + z$	$xy - c$	$dz - a$

$(z - c)^2$	$4a$

$b + c$	$5z - c$

$5z$	bc	$c + z$

$b(d - z)$	$x + b$	$z^2 - c$	z^2	$\frac{dz}{2}$	$d - c$

$b + d$	$3(b + x)$

$x^2 + d$	$16 + y$	$5c$

$y^2 + a$	$2a + 3c$	c^2	$xy + c$	$y^2 + c + z$	$3a - c$	$8 + x$	$3a + z$

$4 + x$	$2d + 2c$	$\frac{10a}{2c}$	$\frac{ab}{d - z}$	$y^2 + z$	$3y^2 + x$	$2x^2 - z$	$d + c$

$\frac{12a}{4}$	$\sqrt{z(b + c)}$

$\frac{d^2 + 2a}{2}$	$\frac{10z}{a}$	$\frac{ad}{d - z}$

y^2	$2b - c$

$x^2 + a + d$	$d + z + y$	$c + d + y$

$\frac{10d}{z - c}$	$2(y)^2$	$2d + x$	$2b + y$	$\frac{b + d}{2}$	$\frac{ad + b}{2}$

$3x^2 - c - d$	$\frac{d^2 + 2y}{4c}$	$x + z$	$\frac{bd}{2} - z$

$\frac{4(d + c)}{2}$	$3d + x$

$15c$	$2(d + c)$	$2x + a + d$

$x + d$	$a - z$	$\frac{y^2(d + c)}{2}$

$2a - c$	$3a + y$	$d - a$	$b - c$	$\frac{d^2}{z}$	$3z + y^2 + y$	$\frac{10a}{2a}$