Three Triangles Integer Factorization Algorithm

> "Discovery consists of seeing what everybody has seen and thinking what nobody has thought."
>
> — Albert Szent-Györgyi

Abstract:

Factor the composite number $C=(a+1)(a+b)$ by finding the solution to $C=T(a)+T(a+b)-T(b-1)$ where $T(n)$ is the nth triangular number.

Definitions:

- a, b := natural numbers
- T(n) := n(n+1)/2
- S(a, b) := T(a)+T(a+b)-T(b-1)
- make_even(n) := if n is odd return n-1 else return n

Theorem:

For every composite number $C=(a+1)(a+b)$ there exist three triangular numbers such that $C=T(a)+T(a+b)-T(b-1)$.

Proof:

1. $(a+1)(a+b)=T(a)+T(a+b)-T(b-1)$
2. $a^2+ab+a+b=a(a+1)/2+(a+b)(a+b+1)/2-(b-1)b/2$
3. $2a^2+2ab+2a+2b=a(a+1)+(a+b)(a+b+1)-(b-1)b$
4. $2a^2+2ab+2a+2b=a^2+a+a(a+b+1)+b(a+b+1)-b^2+b$
5. $2a^2+2ab+2a+2b=a^2+a+a^2+ab+a+ba+b^2+b-b^2+b$
6. $2a^2+2ab+2a+2b=2a^2+2ab+2a+2b$
7. $0=0$

Theorem:

For natural numbers a, b it holds that $S(a, b) > S(a-1, b+1)$.

Proof:

1. $S(a, b) > S(a-1, b+1)$
2. $(a+1)(a+b) > (a+1-1)(a-1+b+1)$
3. $a(a+b)+a+b > a(a+b)$
4. $a+b > 0$

Theorem:

For natural number a, b it holds that $S(a, b) < S(a, b+max(1, ceil((C-S(a, b))/(a+1))))$.

Proof:

1. $S(a, b) < S(a, b+max(1, ceil((C-S(a, b))/(a+1))))$
2. $(a+1)(a+b) < (a+1)(a+b+max(1, ceil((C-S(a, b))/(a+1))))$
3. $a+b < a+b+max(1, ceil((C-S(a, b))/(a+1)))$
4. $0 < max(1, ceil((C - S(a, b))/(a+1)))$
5. $0 < 1$

Algorithm:

input: natural number C
output: found factors, or 1 and C if C is a prime number

1. let a = make_even(floor(sqrt(C)))
2. let b = 1
3. if $S(a, b) > C$ then $a=a-1, b=b+1$
4. if $S(a, b) < C$ then $b=b+max(1, ceil((C-S(a, b))/(a+1)))$
5. if $S(a, b) == C$ then exit: found factors $(a+1)$ and $(a+b)$

6. if *a == 0* then exit: *C* is a prime number
7. goto step 3.

Examples

Factor 51

1. S(6, 1) = 49 => b = b + max(1, ceil(2 / 7))
2. S(6, 2) = 56 => a = a - 2, b = b + 2
3. S(4, 4) = 40 => b = b + max(1, ceil(11 / 5))
4. S(4, 7) = 55 => a = a - 2, b = b + 2
5. S(2, 9) = 33 => b = b + max(1, ceil(18 / 3))
6. S(2, 15) = 51 => 51 = 3 * 17

Factor 23

1. S(4, 1) = 25 => a = a - 1, b = b + 1
2. S(3, 2) = 20 => b = b + 1
3. S(3, 3) = 24 => a = a - 1, b = b + 1
4. S(2, 4) = 18 => b = b + 2
5. S(2, 6) = 24 => a = a - 1, b = b + 1
6. S(1, 7) = 16 => b = b + 4
7. S(1, 11) = 24 => a = a - 1, b = b + 1
8. a = 0 => 23 = 1 * 23

factor 221

1. S(6, 1) = 49 => b = b + 1
2. S(6, 2) = 56 => a = a - 1, b = b + 1
3. S(5, 3) = 48 => b = b + 1
4. S(5, 4) = 54 => a = a - 1, b = b + 1
5. S(4, 5) = 45 => b = b + 2
6. S(4, 7) = 55 => a = a - 1, b = b + 1
7. S(3, 8) = 44 => b = b + 2
8. S(3, 10) = 52 => a = a - 1, b = b + 1
9. S(2, 11) = 39 => b = b + 4
10. S(2, 15) = 51 => 51 = 3 * 17

factor 36

1. S(6, 1) = 49 => a = a - 1, b = b + 1
2. S(5, 2) = 42 => a = a - 1, b = b + 1
3. S(4, 3) = 35 => b = b + 1
4. S(4, 4) = 40 => a = a - 1, b = b + 1
5. S(3, 5) = 32 => b = b + 1
6. S(3, 6) = 36 => 36 = 4 * 9

Conclusion

To my knowledge this is not based on any existing solutions. I do not claim it to be efficient or useful, I'm only concerned with its correctness and completeness. One potential benefit I see is the reduced magnitude of dividends used in divisions. Hope it inspires some ideas.