

1. Find the highest common factor of 12345 and 54321.
2. Find integers x and y with $76x + 45y = 1$. Do there exist integers x and y with $3381x + 2646y = 21$?
3. Prove that if a is coprime to b and also to c then it is coprime to bc . Give two proofs: one based on Euclid's algorithm / Bezout's theorem and one based on prime factorisation.
4. Show that a positive integer n is a multiple of 9 if and only if the sum of its digits is a multiple of 9.
5. The *Fibonacci numbers* F_1, F_2, F_3, \dots are defined by: $F_1 = F_2 = 1$, and $F_n = F_{n-1} + F_{n-2}$ for all $n > 2$ (so eg. $F_3 = 2, F_4 = 3, F_5 = 5$). Is F_{2020} even or odd? Is it a multiple of 3?
6. Solve (ie. find all solutions of) the equations
 - (i) $7x \equiv 77 \pmod{40}$
 - (ii) $12y \equiv 30 \pmod{54}$
 - (iii) $3z \equiv 2 \pmod{17}$ and $4z \equiv 3 \pmod{19}$.
7. An RSA encryption scheme (n, e) has modulus $n = 187$ and coding exponent $e = 7$. By prime-factorising n , find a suitable decoding exponent d . Check your answer (without electronic assistance) by encoding the number 35 and then decoding the result.
8. Explain (without electronic assistance) why 23 cannot divide $10^{881} - 1$.
9. Let p be a prime of the form $3k + 2$. Show that, in \mathbb{Z}_p , the only solution to $x^3 = 1$ is $x = 1$. Deduce, or prove directly, that every element of \mathbb{Z}_p has a cube root.
10. By considering numbers of the form $(2p_1p_2 \dots p_k)^2 + 1$, prove that there are infinitely many primes of the form $4n + 1$.
11. What is the 5th-last digit of $5^{5^{5^5}}$?
12. Is there a positive integer n for which $n^7 - 77$ is a Fibonacci number?
13. Let a and b be distinct positive integers, with $a < b$. Prove that every block of b consecutive positive integers contains two distinct numbers whose product is a multiple of ab . If a, b and c are distinct positive integers, with $a < b < c$, must every block of c consecutive positive integers contain three distinct numbers whose product is a multiple of abc ?
- +14. Let n and k be positive integers. Suppose that n is a k th power (mod p) for all primes p . Must n be a k th power?