

Solutions

Twentieth International Olympiad, 1978

1978/1. Since 1978^n and 1978^m agree in their last three digits, the difference

$$1978^n - 1978^m = 1978^m(1978^{n-m} - 1)$$

is divisible by $10^3 = 2^3 \cdot 5^3$; and since the second factor above is odd, 2^3 divides the first. Also

$$1978^m = 2^m \cdot 989^m,$$

so $m \geq 3$.

We can write $m + n = (n - m) + 2m$; to minimize this sum, we take $m = 3$ and seek the smallest value of $d = n - m$, such that $1978^d - 1$ is divisible by $5^3 = 125$, i.e.

$$1978^d \equiv 1 \pmod{125}.$$

We shall twice make use of the following

LEMMA. *Let d be the smallest exponent such that $a^d \equiv 1 \pmod{N}$. Then any other exponent g for which $a^g \equiv 1 \pmod{N}$ is a multiple of d .*

PROOF: If d does not divide g , then $g = qd + r$ with $0 < r < d$, and $a^g \equiv a^{qd}a^r \equiv 1 \pmod{N}$ implies $a^r \equiv 1 \pmod{N}$ with $0 < r < d$, contradicting the minimality of d . So $d|g$.

Fermat's theorem states:† For any prime p and any integer a not divisible by p ,

$$(1) \quad a^{p-1} \equiv 1 \pmod{p}.$$

For example,

$$1978^4 \equiv 1 \pmod{5}.$$

†For a proof, see e.g. p. 126 of S. L. Greitzer, *The International Mathematical Olympiads*, vol. 27 in this NML series.

Math Olympiad Problems And Solutions

Xiong-hui Zhao



Math Olympiad Problems And Solutions:

Math Olympiad Problems And Solutions Book Review: Unveiling the Magic of Language

In an electronic era where connections and knowledge reign supreme, the enchanting power of language has become more apparent than ever. Its power to stir emotions, provoke thought, and instigate transformation is truly remarkable. This extraordinary book, aptly titled "**Math Olympiad Problems And Solutions**," published by a very acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound impact on our existence. Throughout this critique, we will delve into the book's central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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