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- Math Interview Problems
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math based top 15 problem commonly asked in interview questions.  
give input and output of the problem.  
list 5 easy, 5 medium, 5 hard difficulty problems.

- use below as reference:
- Introduction
  - Complete Bitwise Operators
  - Prime numbers
  - HCF / LCM
  - Sieve of Eratosthenes
  - Newton's Square Root Method
  - Number Theory
  - Euclidean algorithm
  - Advanced Concepts for CP (later in the course)
  - Bitwise + DP
  - Extended Euclidean algorithm
  - Modulo Properties
  - Modulo Multiplicative Inverse
  - Linear Diophantine Equations
  - Fermat's Theorem
  - Wilson's Theorem
  - Lucas Theorem
  - Chinese Remainder Theorem

 Get citation

Here's a list of math-based problems commonly asked in interviews, categorized by difficulty. Each problem includes a brief description, input, and expected output.

### Easy Problems

#### 1. Prime Number Check

- **Description:** Determine if a given number is a prime number.
- **Input:** `n` (integer)
- **Output:** `True` if `n` is prime, `False` otherwise.
- **Example:**
  - Input: `7`
  - Output: `True`

#### 2. Find GCD (Greatest Common Divisor)

- **Description:** Find the GCD of two numbers using the Euclidean algorithm.
- **Input:** `a, b` (integers)
- **Output:** GCD of `a` and `b`.
- **Example:**
  - Input: `56, 98`
  - Output: `14`

#### 3. Check for Perfect Square

- **Description:** Check if a given number is a perfect square.
- **Input:** `n` (integer)
- **Output:** `True` if `n` is a perfect square, `False` otherwise.
- **Example:**
  - Input: `16`
  - Output: `True`


#### 4. Find LCM (Least Common Multiple)

- **Description:** Find the LCM of two numbers using their GCD.
- **Input:** `a, b` (integers)
- **Output:** LCM of `a` and `b`.

- **Example:**

- Input: `4, 5`
- Output: `20`

## 5. Check for Palindrome Number


- **Description:** Determine if a given number is a palindrome.
- **Input:** `n` (integer)
- **Output:** `True` if `n` is a palindrome, `False` otherwise.
- **Example:** 
- Input: `121`
- Output: `True`

## Medium Problems

### 1. Generate Primes Using Sieve of Eratosthenes

- **Description:** Generate all prime numbers up to a given number `n`.
- **Input:** `n` (integer)
- **Output:** List of primes up to `n`.
- **Example:**
- Input: `10`
- Output: `[2, 3, 5, 7]`


### 2. Find Modular Inverse

- **Description:** Find the modular multiplicative inverse of `a` modulo `m`.
- **Input:** `a, m` (integers) 
- **Output:** Modular inverse of `a` mod `m`, if it exists.
- **Example:**
- Input: `3, 11`
- Output: `4`

### 3. Check for Fermat's Little Theorem

- **Description:** Check if Fermat's Little Theorem holds for a given base and prime.
- **Input:** `a, p` (integers, where `p` is a prime)
- **Output:** `True` if  $a^{(p-1)} \equiv 1 \pmod{p}$ , `False` otherwise.
- **Example:**
- Input: `2, 7`
- Output: `True`

### 4. Extended Euclidean Algorithm

- **Description:** Find the coefficients  $x, y$  such that  $ax + by = \gcd(a, b)$ .  Bézout's identity (i.e., `x` and `y` such that `ax + by = gcd(a, b)`).
- **Input:** `a, b` (integers)
- **Output:** Coefficients `x`, `y` and `gcd(a, b)`.
- **Example:**
- Input: `30, 20`
- Output: `(1, -1, 10)`

### 5. Find All Divisors of a Number

- **Description:** Find all divisors of a given number.
- **Input:** `n` (integer)
- **Output:** List of all divisors of `n`.
- **Example:**
- Input: `28`

- Output: `[1, 2, 4, 7, 14, 28]`



## Hard Problems

### 1. Chinese Remainder Theorem

- **Description:** Solve a system of simultaneous congruences.
- **Input:** List of remainders and moduli.
- **Output:** Solution  $x$  such that  $x \equiv a_i \pmod{m_i}$  for all given congruences.
- **Example:**
  - Input: `[(2, 3), (3, 5), (2, 7)]`
  - Output: `23`

### 2. Linear Diophantine Equations

- **Description:** Find integer solutions for the equation  $ax + by = c$ .
- **Input:** `a, b, c` (integers)
- **Output:** Integer solutions  $x$  and  $y$  if they exist.
- **Example:**
  - Input: `6, 15, 3`
  - Output: `(1, -1)`



### 3. Lucas Theorem for Combinations Modulo a Prime

- **Description:** Calculate combinations modulo a prime using Lucas' theorem.
- **Input:** `n, k, p` (integers where `p` is a prime)
- **Output:**  $\binom{n}{k} \pmod{p}$
- **Example:**
  - Input: `5, 2, 7`
  - Output: `3`

### 4. Wilson's Theorem

- **Description:** Verify if a number is prime using Wilson's theorem, which states  $(p-1)! \equiv -1 \pmod{p}$  for a prime `p`.
- **Input:** `p` (integer)
- **Output:** `True` if `p` is prime according to Wilson's theorem, `False` otherwise.
- **Example:**
  - Input: `5`
  - Output: `True`



### 5. Modulo Properties in Large Exponentiation

- **Description:** Compute  $a^b \% m$  efficiently using modular exponentiation.
- **Input:** `a, b, m` (integers)
- **Output:** Result of  $a^b \pmod{m}$ .
- **Example:**
  - Input: `3, 200, 1000`
  - Output: `1`

These problems cover a range of mathematical concepts and algorithms commonly encountered in coding interviews.

