What Is A Prime? From Primes To Riemann

Tariq Rashid

January 14, 2021

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Counting Numbers

$$1, 2, 3, 4, 5, 6, 7, 8, \dots$$

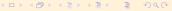
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Multiplication

$$2 \times 4 = 8$$

 $5 \times 5 = 25$



Factors & Products

$$3 \times 4 = 12$$

- 3 and 4 are factors
- 12 is a product

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Multiplying Whole Numbers

$$a \times b = c$$

• if a and b are whole numbers, so is c



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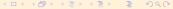
$$a \times b = c$$

- a and b can be any counting number we feel like choosing
- does c have this freedom too?

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$$a \times b = 12$$

- a = 3, b = 4
- a = 2, b = 6



$$a \times b = 100$$

- a = 2, b = 50
- a = 10, b = 10



$$a \times b = 7$$

- *a* =?, *b* =?
- no solutions!



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$$a \times b = 11$$

- a =?, b =?
- no solutions !
- These numbers 7 and 11 are prime numbers.

Prime Numbers

$$2, 3, 5, 7, 11, 13, 19, 23, 29, 31, 37, 41, 43, 47, 53, \dots$$

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What About 1?

$$1 \times 7 = 7$$

- We exclude 1 as a legitimate factor.
- If we didn't, there would be no prime numbers because every number would have a factor of 1



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What About 1?

Even worse...

$$12 = 3 \times 4$$
 $12 = 3 \times 4 \times 1$
 $12 = 3 \times 4 \times 1 \times 1 \times 1 \times 1$
 $12 = 3 \times 4 \times 1 \times \dots$

Negative Primes?

History:

- prime numbers were known about and discussed in ancient times ...
- .. before the idea of a negative number was accepted

Apparent Randomness

```
2,3,5,7,11,13,17,19,23,29
31,37,41,43,47,53,59,61,67,71
73,79,83,89,97,101,103,107,109,113
127,131,137,139,149,151,157,163,167,173
179,181,191,193,197,199,211,223,227,229
233,239,241,251,257,263,269,271,277,281
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ullet No apparent pattern o hard to predict next prime