Elliptic Curve Cryptography

David Wolever
@wolever

what is a cryptography

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that’s easy

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133498471 9824

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133498471982⁴

⊕ hello, world!

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133498471982 4

⊕ hello, world!

blaiiaieuaoaf

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otp: one true ciPher

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otp: one time pad

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problem

numbers are hard

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~~numbers are hard~~

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sharing numbers is hard

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enter: public key cryptography

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pick a secret number

while you're listening

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dh: Diffie–Hellman

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$$A^b \% p = g^{ab}$$

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We agree on:

p: a *prime modulus* (ex: 23)

g: a *primitive root base* (ex, 5)

You (Alice) and I (bob)
Pick secret numbers:
a: Alice's number (ex, 32)
b: Bob's number (ex, 16)

We each calculate:

$$A = g^a \% p$$
$$A = 5^{32} \% 23$$

$$B = g^b \% p$$
$$B = 5^{16} \% 23$$

We share A and B
(that’s right, you can hear
them)

We each calculate:

$$s = A^b \% p$$

$$s = B^a \% p$$

and because *math*

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We get the same number:

$$
\begin{aligned}
s &= A^b \,\%\, p \\
&= (g^a \,\%\, p)^b \,\%\, p \\
&\equiv g^{ab} \,\%\, p \\
&\equiv (g^b \,\%\, p)^a \,\%\, p \\
&\equiv B^a \,\%\, p
\end{aligned}
$$

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magic

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enter: elliptic curves

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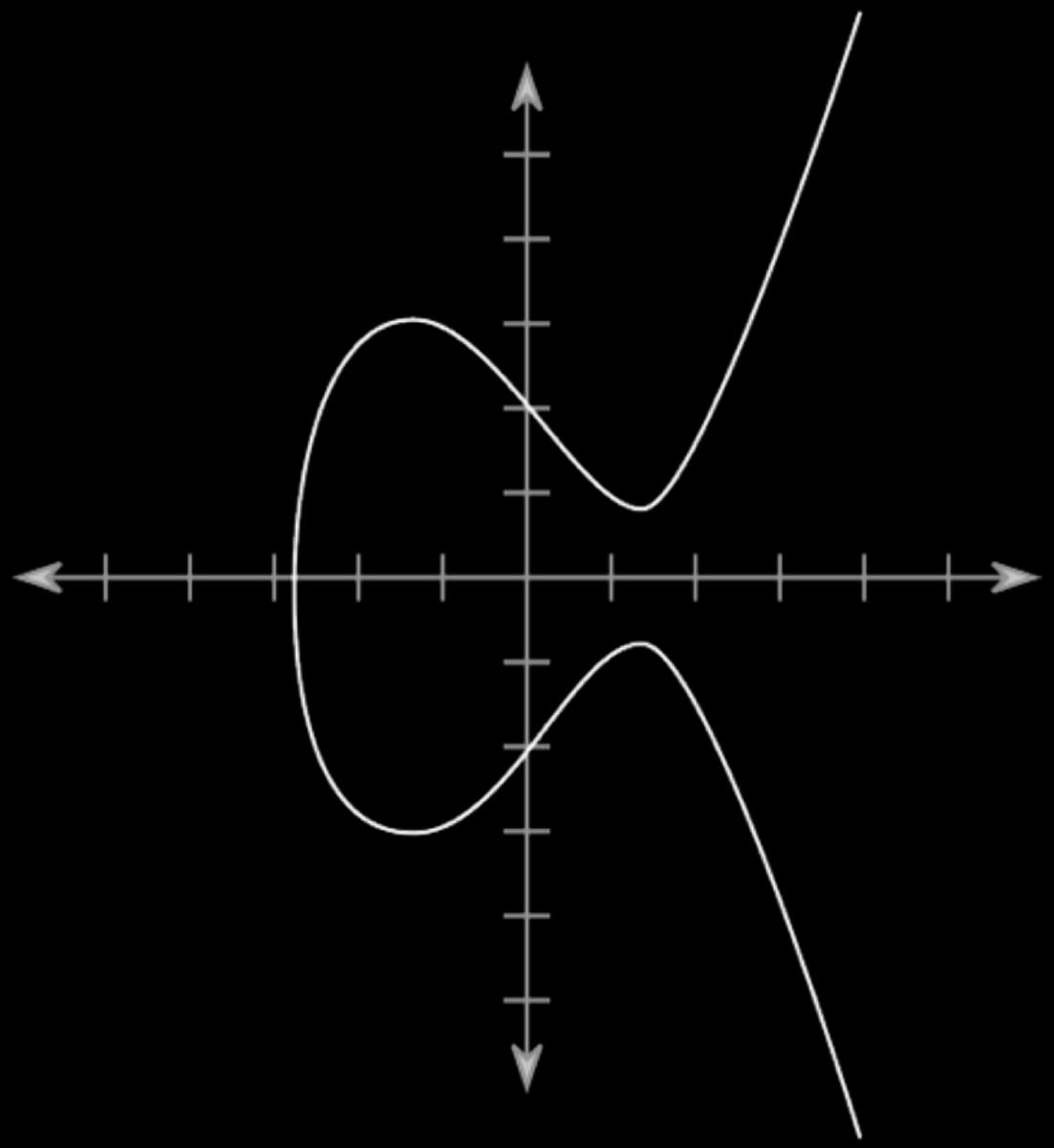

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300 bit ec key ≈

3000 bit dh key

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1. pick a curve

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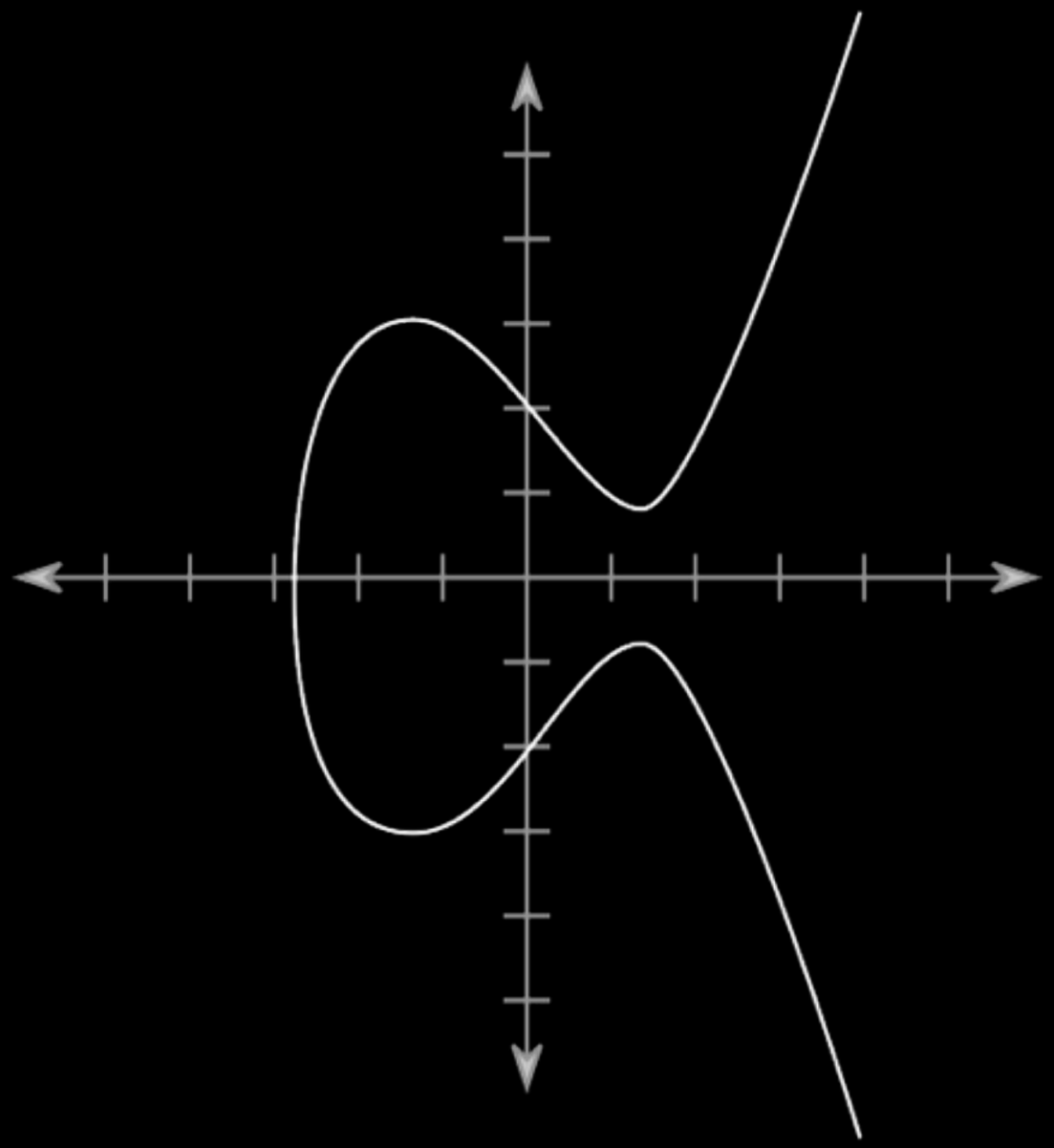
$$y^2 = x^3 + 7$$



(not actually $y^2 = x^3 + 7$)

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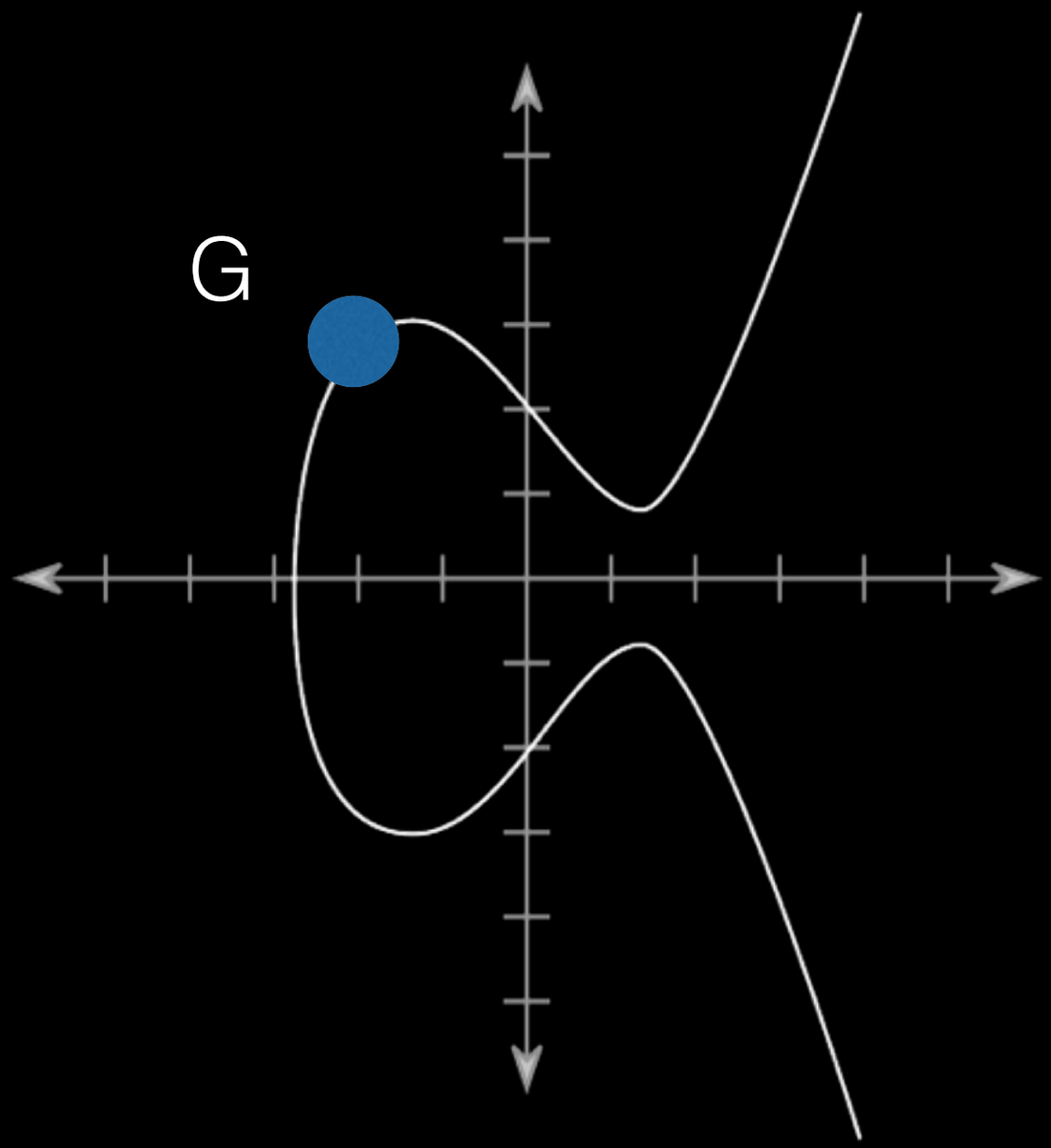
2. pick a base point



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3. we each pick a secret, random number (*a* and *b*)

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3. multiply the base point by that number

$$A = G \times a$$

$$B = G \times b$$

… multiply a point?

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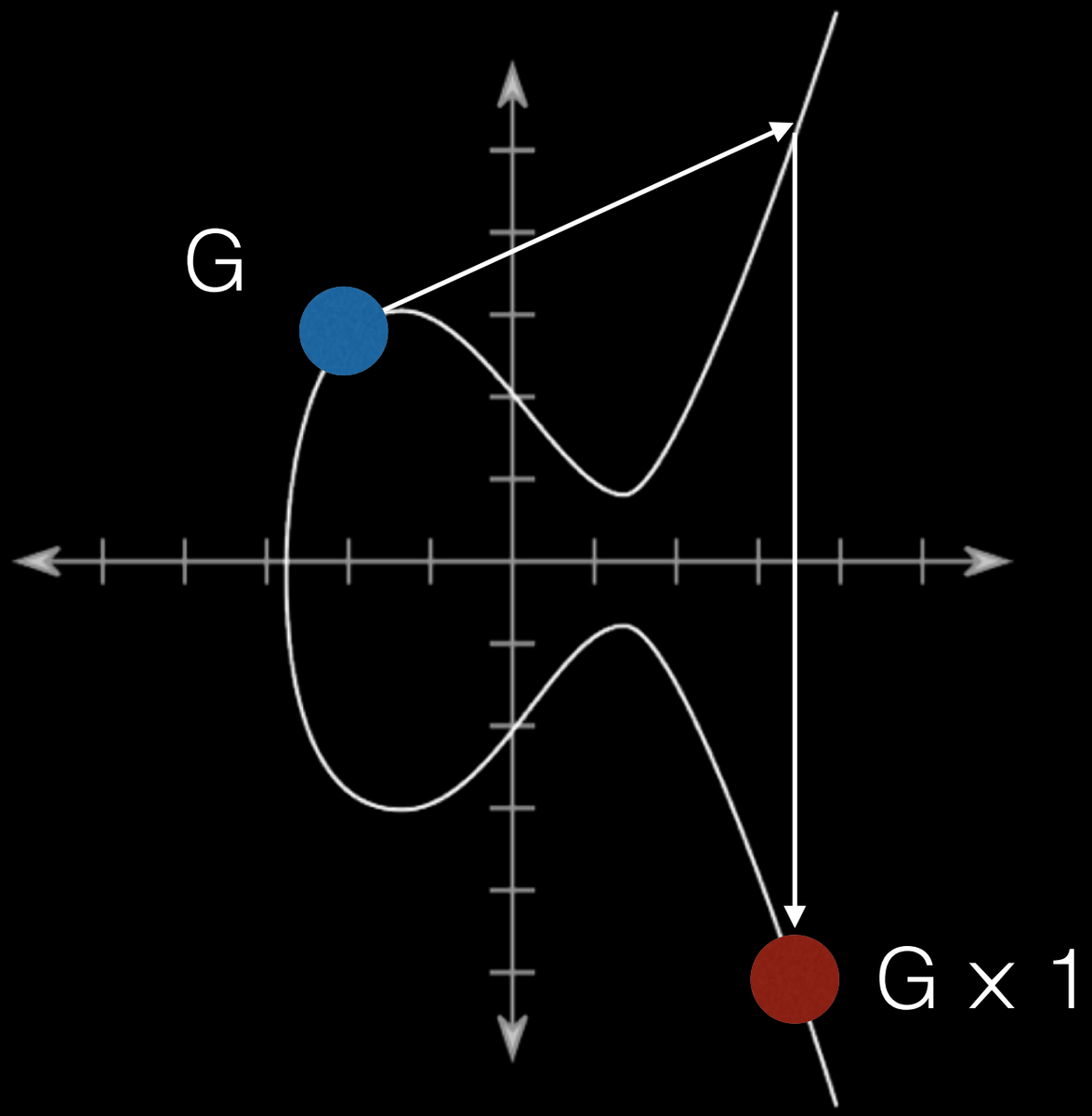

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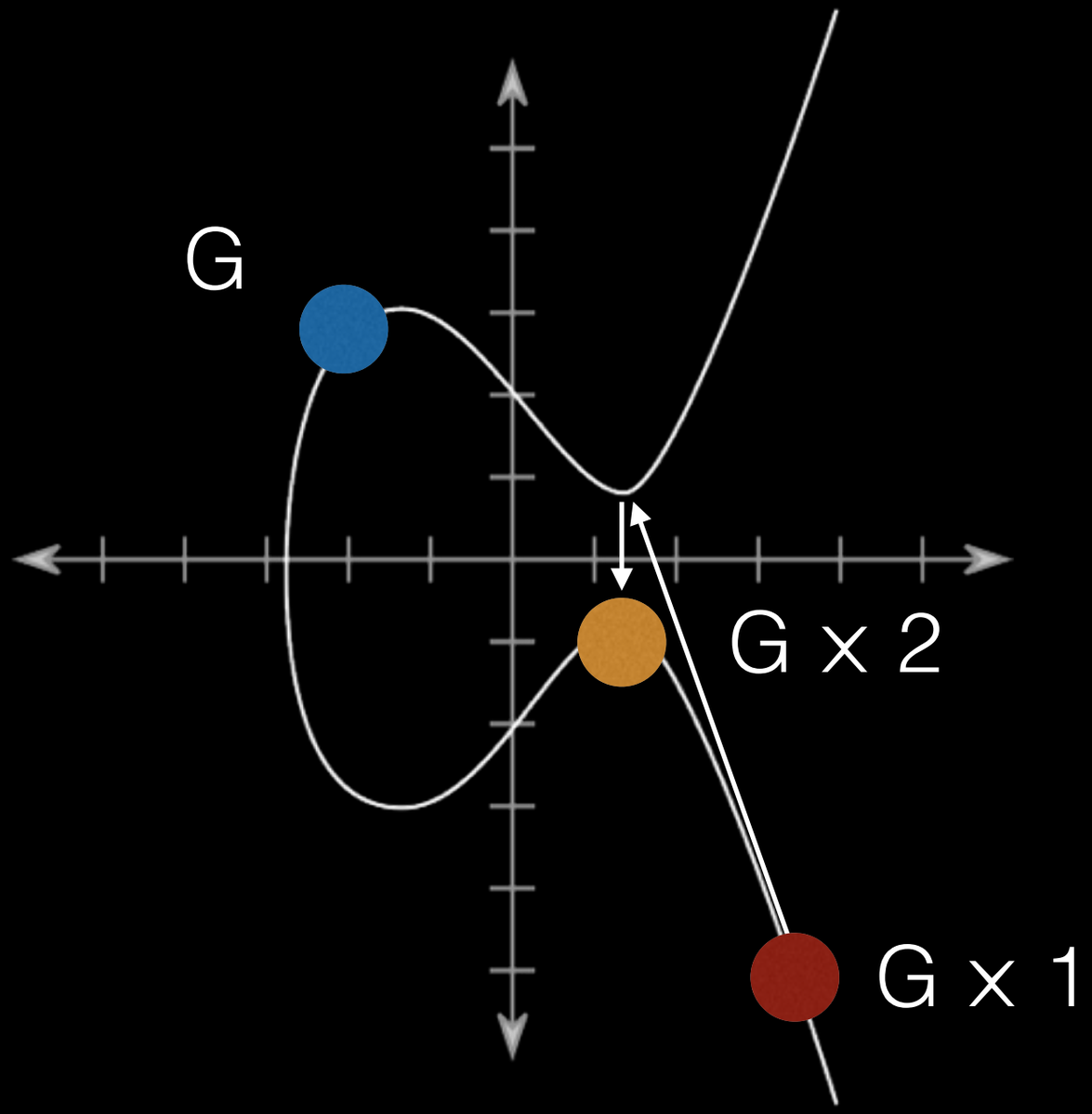

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3. multiply the base point by that number

$$A = G \times a$$

$$B = G \times b$$

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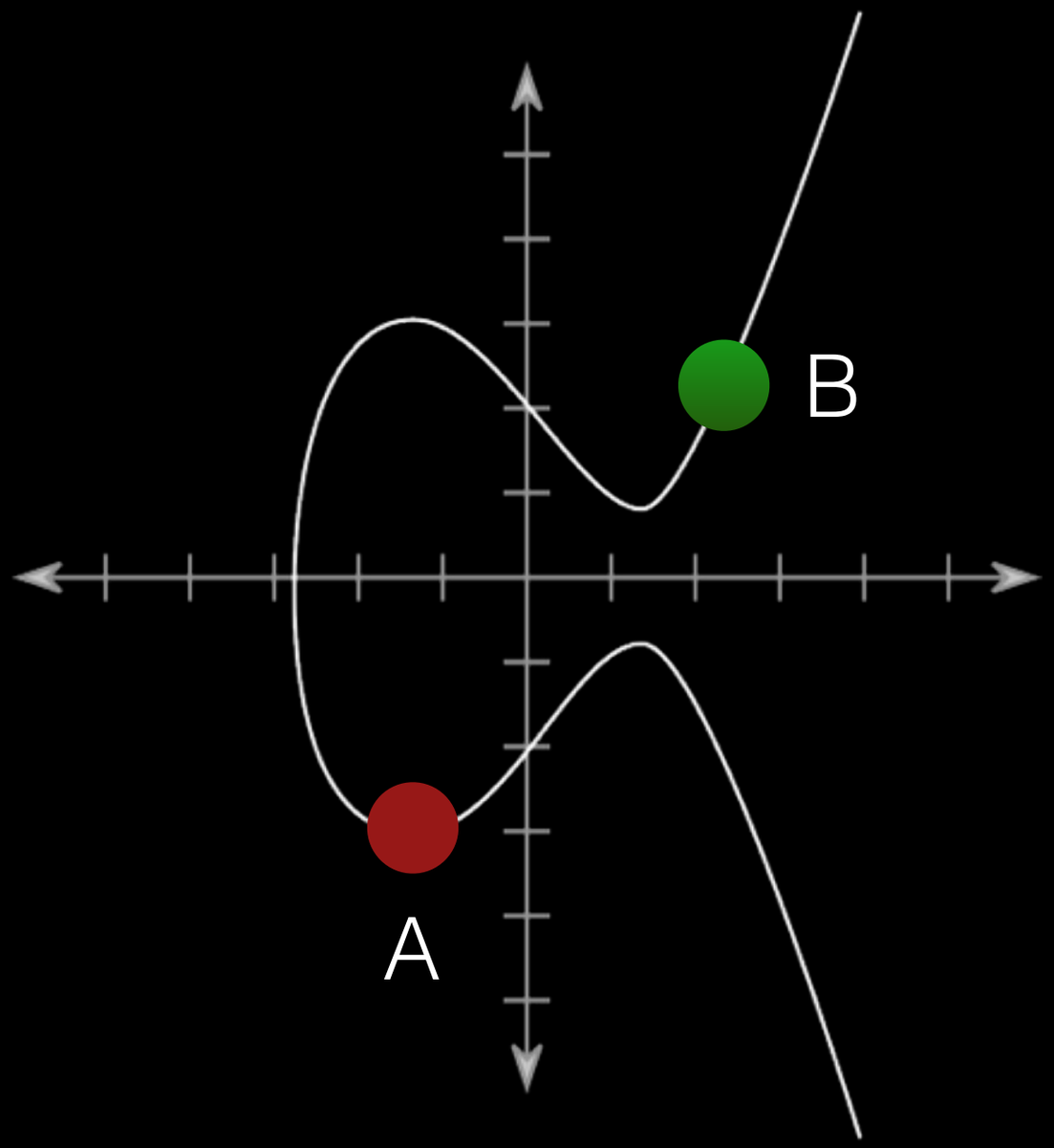

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4. share those points

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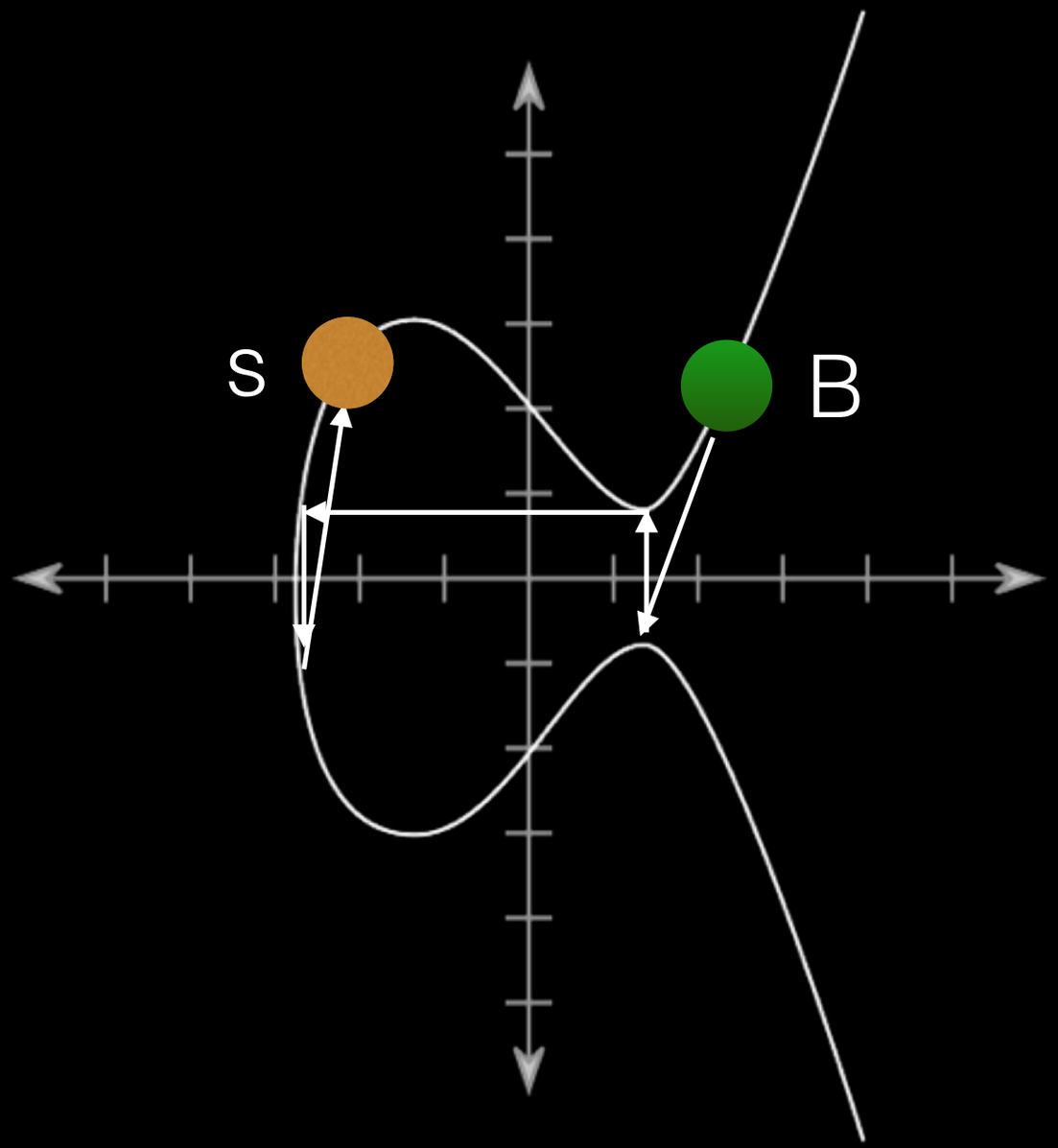
5. multiply the points by our secret numbers

$$s = A \times b$$

$$s = B \times a$$



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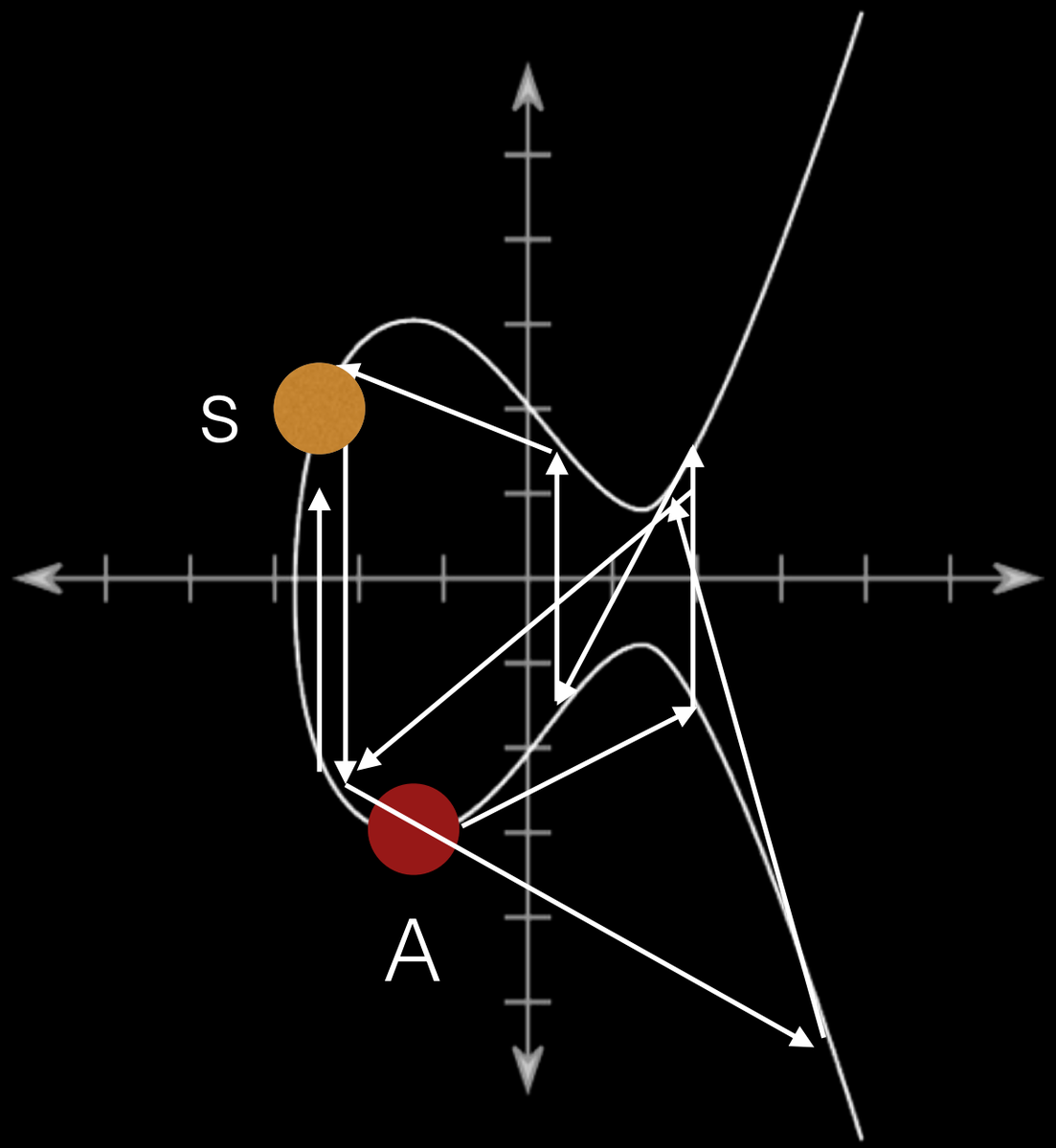

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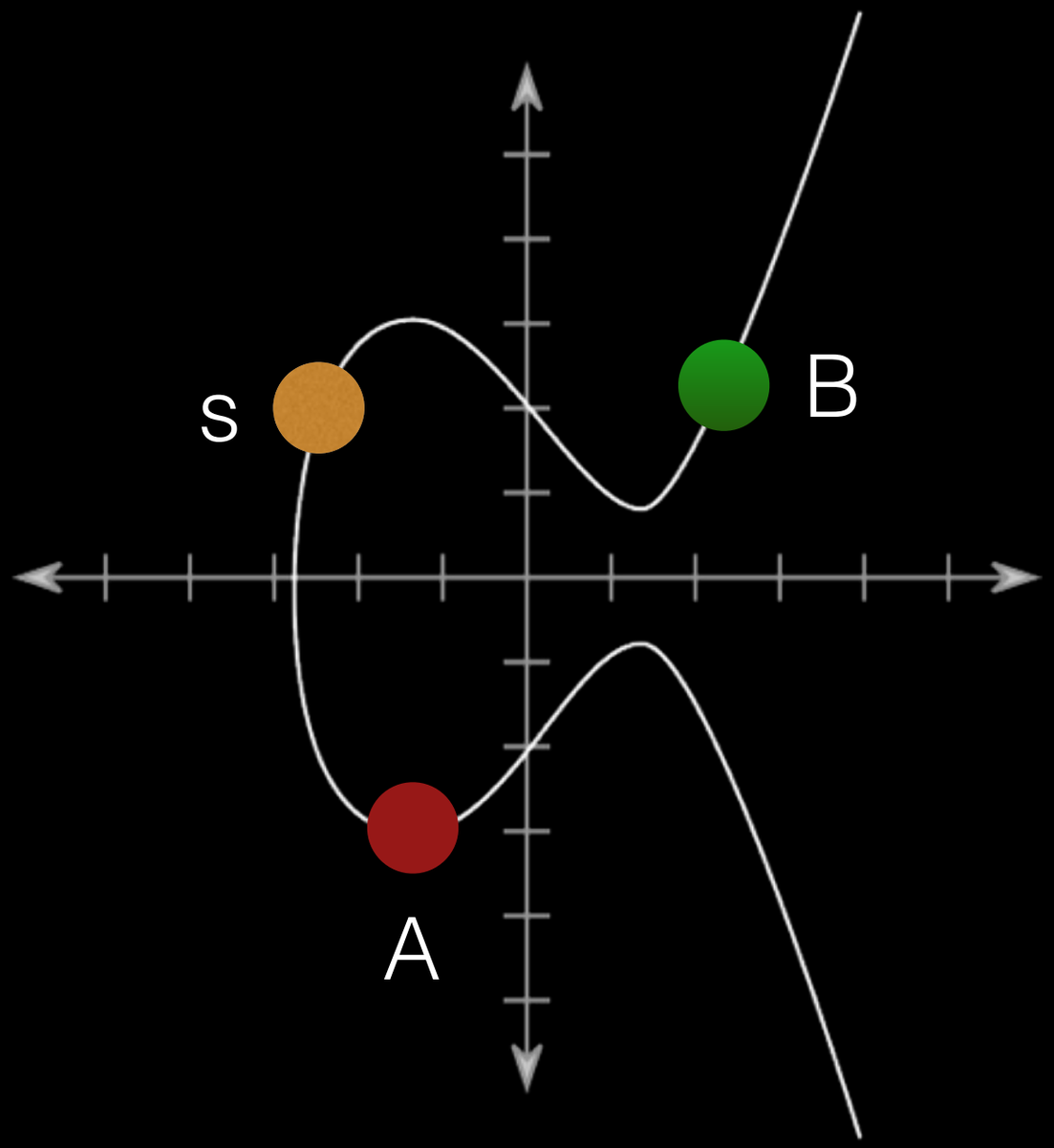

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really not *that* hard!

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... but

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DO ***NOT*** DO THIS YOURSELF

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libsodium cryptography

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```
>>> from cryptography.fernet import Fernet
>>> # Put this somewhere safe!
>>> key = Fernet.generate_key()
>>> f = Fernet(key)
>>> token = f.encrypt(b"A really secret message. Not for
prying eyes.")
>>> token
'...'
>>> f.decrypt(token)
'A really secret message. Not for prying eyes.'
```

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