Calculating transformer turns

Say we have a transformer with an iron core of 10x10 cm cross-section (0.01m2)

max flux density of iron is around 1T so the maximum flux allowed is:

$\phi_{max} = 0.01 * 1 = 0.01Wb$

the transformer operates at 230Vrms @50Hz meaning:

$Vpeak = 230 * \sqrt{2} = 325V \quad \text{and} \quad \omega = 2\pi f = 2\pi * 50 = 314$

the flux waveform can be represented as:

$\phi(t) = 0.01\sin(314t)$

“rate of change” is the derivative in maths, which is:

$\phi'(t)\ (\text{or } d\phi/dt) = 3.14\cos(314t)$

we want to know the rate of change at t = 0.01s (max negative slope)

$\phi'(0.01) = 3.14\cos(314 * 0.01) = -3.14$

Plug this into Faraday’s law with our peak voltage:

$V = -N * \ d\phi/dt = 325 = -N * -314$

we can then calculate that N = 103

This is the long way round. Doing all the maths it turns out you can combine everything into one neat equation, known by some as the transformer EMF equation:

$Vrms = 4.44 * f * \phi_{max} * N$

filling in our numbers:

$4.44 * 50 * 0.01 * 103 = 230Vrms$ (which is indeed the correct voltage)