QFT model = $E$ \& $M$

need to know Everything about $E$ \& $M$!

so Classical $E$ \& $M$ described by

I) Maxwell’s equations

$$\nabla \cdot E = \frac{\rho}{\varepsilon_0}$$
$$\nabla \cdot B = 0$$
$$\nabla \times E = -\frac{\partial B}{\partial t}$$
$$\nabla \times B = \mu_0 \frac{\partial E}{\partial t} + \mu_0 \varepsilon_0 \frac{\partial B}{\partial t}$$

II) Better, “Covariant” \& vectors

$F^{\mu\nu} = $ Field Tensor

$$\frac{\partial F^{\mu\nu}}{\partial x^\mu} = \mu_0 j^{\nu}$$
$$\frac{\partial F^{\mu\nu}}{\partial x^\nu} = 0$$

=
Note if you take \( \text{curl} \) of
\[
\nabla \times (\nabla \times \mathbf{E}) = -\frac{\partial \mathbf{B}}{\partial t}
\]

get
1) \( \nabla^2 \mathbf{E} = \mu_0 \mathbf{E}_0 \frac{\partial^2 \mathbf{E}}{\partial t^2} \)

2) \( \nabla^2 \mathbf{B} = \mu_0 \mathbf{E}_0 \frac{\partial^2 \mathbf{B}}{\partial t^2} \)

Recognize
\[
\frac{\partial^2 \phi}{\partial x^2} = \frac{1}{v^2} \frac{\partial^2 \phi}{\partial t^2} \quad \Rightarrow \quad \begin{array}{c}
\text{wave on string} \\
\text{\( \phi \) velocity}
\end{array}
\]
\[
1 \frac{1}{v} \Rightarrow \quad \mathbf{E} \frac{1}{v} \mathbf{B} = \text{waves} \quad \text{\( \mathbf{E} \)}
\]
\[
1 \frac{1}{v_{\mu_0 \mathbf{E}_0}} = \frac{1}{3 \times 10^8} \, \text{m/s}
\]
Since $1 \frac{1}{2}$ do not depend on absolute $x_0, t_0, \Sigma_0$. 

This you should get $C$ from all inertial frames. i.e. Special Relativity!
So Math! Laws of Physics =
inherently mathematical
≠ #
But the "Forms" of
physical law!

Idea is that "true" laws of
physics will look the same to
everyone! Forms of laws =
invariant to translations
to other frames!

Indeed Max's Equations are invariant
to transformations that mix
space & time = (R², t)
= Lorentz transformation.
That $\Rightarrow$ when you observe moving frames

- time slows down, $St \rightarrow \text{Bigger}
- \text{length diameters, } St \rightarrow \text{smaller}$
Finally Math.

Real #s (IR), -5, -4, ..., 0, 1, 2, ...

Rational #s \( \frac{IR\#}{IR\#} \Rightarrow \) Repeating decimal

\[ \overline{.500000} = \frac{5}{10} \]

Irrational #s

\[ a \neq 0 \quad x^2 = 9 \quad x = \pm 3 \]

\[ x^2 = 2 \quad \text{No Rational} \quad \# \text{ soln!} \]

\[ \text{invent} \quad \sqrt{2}, \text{ so that} \]

\[ (\sqrt{2})^2 = 2 \]

\[ \sqrt{2} = \text{irrational} \# \quad \text{No repeating decimal} \quad \text{equiv} \]

ex: \( \pi \)
Complex numbers

ask \( x^2 = -1 \) No rational or
irrational is
again "invent"

\( i^2 = -1 \)

complex numbers are vectors

\( z = x + iy \)

\[ |z| = \sqrt{z \cdot z^*} = \sqrt{(x-iy)(x+iy)} = \sqrt{x^2 + y^2} \]