HW!

\[
\frac{d^2 x}{dt^2} = \frac{A}{x^2} \\
-\frac{dx}{dt} = \sqrt{2A} \sqrt{\frac{1}{x} - \frac{1}{d}} \text{ blows up}
\]

\[A = \frac{2}{3} = \pi\]

Well, it does blow up because mirror charges annihilate each other. Proceed by separation of variables.

**Special Relativity**

- \(c\) is constant
- all inertial reference frames \((a = 0 = F)\) are equivalent

Einstein worked as a clerk in a patent office!
Galilean Transformation (Switch frames of Reference)

Suppose there is a space ship traveling with velocity in \( \hat{x} \).

\[
\begin{align*}
    x' &= x - vt \\
    y' &= y \\
    z' &= z \\
    t' &= t
\end{align*}
\]

\[(x', y', z', t') = (x - vt, y, z, t)\]

Lorentz Transformation

Now, move space shuttle relativistically.

\[
\begin{align*}
    x' &= A x + B t = 1 A(x - ut) \\
    y' &= y \\
    z' &= z \\
    t' &= D x + E t = 2 D x + At = 3 - \frac{Au}{c^2} x + At \\
    t' &= A(\frac{-u}{c^2} x + t) \\
    \gamma &= \frac{1}{\sqrt{1 - \frac{u^2}{c^2}}}
\end{align*}
\]
\[ x' = 0 \]
\[ Ax + Bt = 0 \]
\[ Au + Bt = 0 \]
\[ Au = -B \]
\[ B = -Au \]

\[ x' = -ut' \quad \text{at shuttle looking at ESG} \]
\[ -u(Dx + Et) = A(x - ut) \quad x = 0 \]
\[ -uEt = -uAt \]
\[ E = A \]

\[ x' = ct' \]
\[ A(x - ut) = c(Dx + At) \]
\[ A(ct - ut) = c(Dct + At) \]
\[ A(c - u) = c(Dc + A) \]
\[ Ac - Au = c^2D + Ac \]
\[ D = -\frac{Au}{c^2} \]
\[ x^2 + y^2 = (ct)^2 \quad x = 0 \]
\[ \Rightarrow y = ct \]
\[ x'^2 + y'^2 = (ct')^2 \]
\[ A^2(x - ut)^2 + c^2 t^2 = c^2 A^2 \left( \frac{-u}{c^2} + t \right)^2 \]
\[ A^2 u^2 t^2 + c^2 t^2 = c^2 A^2 t^2 \]
\[ A^2 u^2 + c^2 = c^2 A^2 \]
\[ A^2 = \frac{c^2}{u^2 - c^2} \]
\[ A = \frac{1}{\sqrt{1 - \frac{u^2}{c^2}}} = \gamma \]

Also use \( \beta = \frac{u}{c} \)

- How fast do you need to go for special relativity to apply? Look at \( \gamma : v \), Need to be at least 30\% of speed of light.

( Also, in \( t' = \gamma \left( \frac{-u}{c^2} x + t \right) \), \( \frac{-u}{c^2} \) is usually very small).
World Lines

This cone of permitted casualty tells us that information can travel no faster than the speed of light

In our frame, 0 and 0 are at different times
In space shuttle, 0 and 0 are at the same time