

$x = x_c x^*$, $t = t_c t^*$, $u = u_c u^*$

$u = 1$

$\frac{\partial^4}{\partial x^4} = \frac{1}{x_c^4} \frac{\partial^4}{\partial x^{*4}}$, $\frac{\partial^2}{\partial t^2} = \frac{1}{t_c^2} \frac{\partial^2}{\partial t^{*2}}$

$E I \frac{u_c}{x_c^4} \frac{\partial^4 u^*}{\partial x^{*4}} + \rho \frac{u_c}{t_c^2} \frac{\partial^2 u^*}{\partial t^{*2}} = 0$

$\frac{E I t_c^2}{\rho x_c^4} ?$ $\left(\frac{I}{x_c^4} \right)$

$E = f(I, \rho, t_c, x_c)$
 $E = \frac{\rho}{t_c^2} \left(\frac{I}{x_c^4} \right)^a \Rightarrow E \propto \left(\frac{\rho}{t_c^2} \right) F \left(\frac{I}{x_c^4} \right)$ $4-3=1$

$f(E, I, \rho, t_c, x_c) = 0$

$E / (\rho / t_c^2)$

$5-3=2$

$u_c = f(E, I, \rho, t_c, x_c)$

\Rightarrow $\text{maximally } \pi_3 = t_c \omega$

B.C. $\left. \begin{array}{l} u^* = u_0 / u_c \sin(\omega t_c t^*) \\ \frac{\partial u^*}{\partial x^*} = 0 \\ u^* = 0 \\ \frac{\partial u^*}{\partial x^*} = 0 \end{array} \right\} @ x^* = 0$

$\left. \begin{array}{l} \end{array} \right\} @ x^* = l / x_c$

I.C. $\left\{ \begin{array}{l} u^* = 0 \\ \frac{\partial u^*}{\partial t^*} = 0 \end{array} \right. @ t^* = 0$

$\pi_1 = u_0 / u_c = 1$

$u_c = u_0$

$\pi_2 = \omega t_c = 1$

$\Rightarrow t_c = 1 / \omega$

$\pi_3 = l / x_c = 1$

$x_c = l$

$\frac{E}{\rho \omega^2} \frac{\partial^4 u^*}{\partial x^{*4}} + \frac{l^4}{I} \frac{\partial^2 u^*}{\partial t^{*2}} \Rightarrow$

B.C. $\left. \begin{array}{l} u^* = \sin t^* \\ \frac{\partial u^*}{\partial x^*} = 0 \\ u^* = 0 \\ \frac{\partial u^*}{\partial x^*} = 0 \end{array} \right\} @ x^* = 0$

$\left. \begin{array}{l} \end{array} \right\} @ x^* = 1$

I.C. $\left\{ \begin{array}{l} u^* = 0 \\ \frac{\partial u^*}{\partial t^*} = 0 \end{array} \right. @ t^* = 0$