Let's go back to the earlier equation we developed for the thermocouple in the fluid to see how the Laplace transform can be used, i.e.

$$\tau \frac{d\Delta T_s}{dt} + \Delta T_s = \Delta T_f$$

We can carry out a Laplace Transform on it, term by term, to give

$$\tau\left[s\Delta \overline{T}_s(s) - \Delta T_{-0}\right] + \Delta \overline{T}_s(s) = \Delta \overline{T}_f(s)$$

where $\Delta \overline{T}$ is the Laplace transform of ΔT

ΔT_{-0} = the temperature difference at initial conditions immediately prior to $t = 0$ (if you remember we set this to be 0).

So $$\tau\left[s\Delta \overline{T}_s(s)\right] + \Delta \overline{T}_s(s) = \Delta \overline{T}_f(s)$$

or $$\Delta \overline{T}_s(s)\left[\tau s + 1\right] = \Delta \overline{T}_f(s)$$

If we consider $\Delta \overline{T}_s(s)$ as the output and $\Delta \overline{T}_f(s)$ as the input we can determine the **transfer function(output/input)** or **gain** for this system in the s domain as

$$G(s) = \frac{\Delta \overline{T}_s(s)}{\Delta \overline{T}_f(s)} = \frac{1}{\tau s + 1}$$

and can represent this on a block diagram (compare this with our earlier work in Topic 1 and 2 on control systems diagrams).

$$\Delta \overline{T}_f(s) \longrightarrow \boxed{\frac{1}{\tau s + 1}} \longrightarrow \Delta \overline{T}_s(s)$$