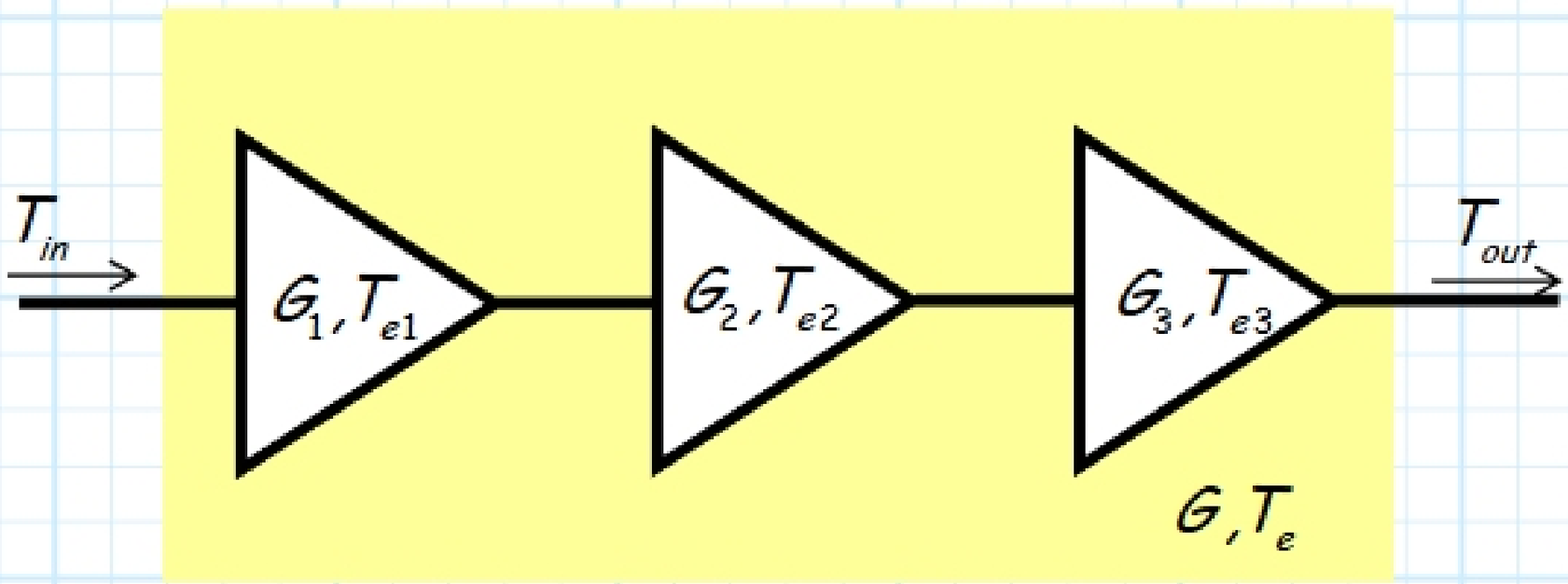
# System Equivalent Noise Temperature

Say we **cascade** three microwave devices, each with a different **gain** and **equivalent noise temperature**:




These three devices together can be thought of as **one** new microwave device.

**Q:** *What is the equivalent noise temperature $T_e$ of this **overall** device?*

**A:** First of all, we must d**efine** this temperature as the value $T_e$ such that:

$$T_{out} = G(T_{in} + T_e)$$

or specifically:

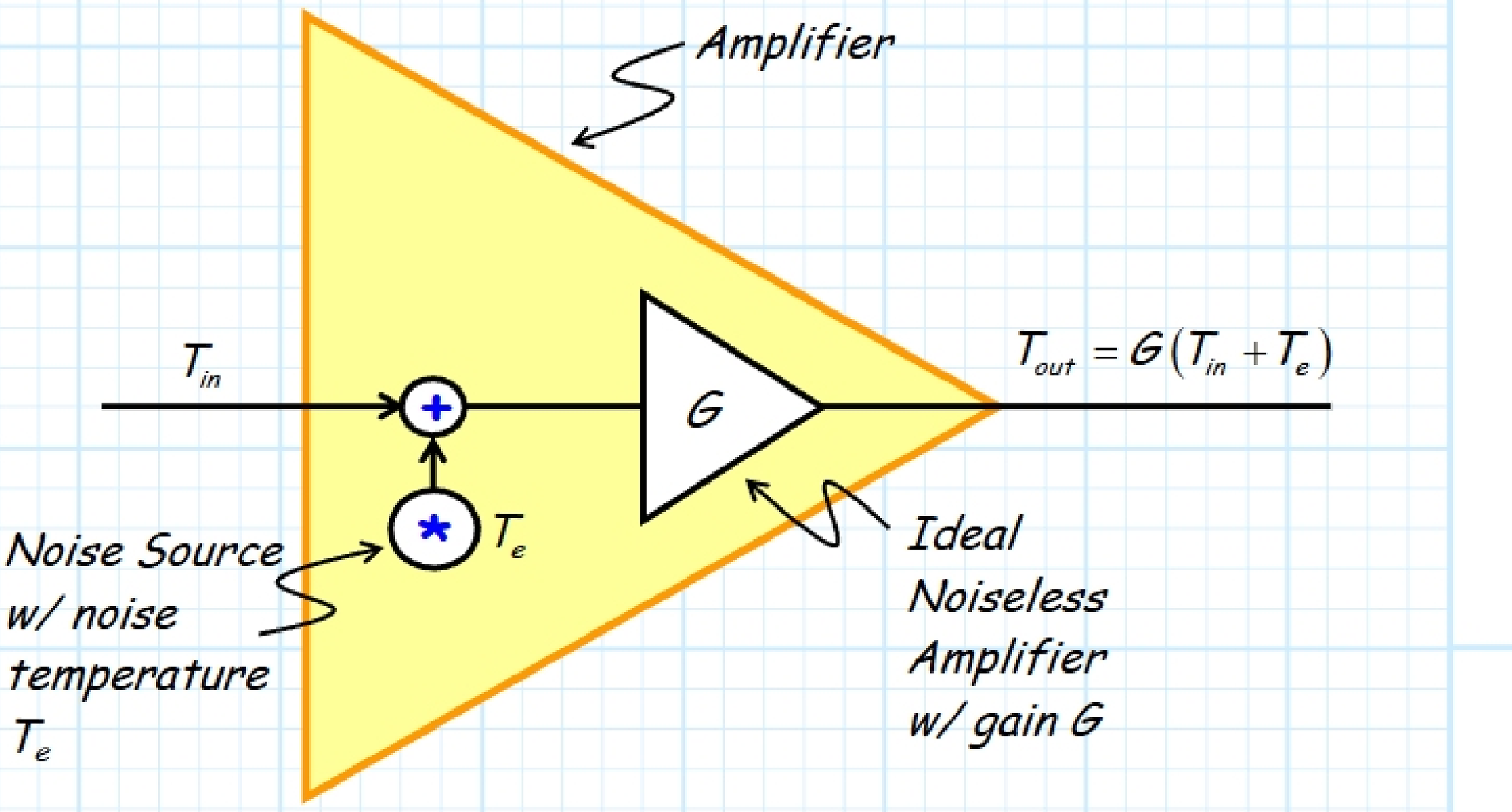
$$T_e = \frac{T_{out}}{G} - T_{in}$$

**Q:** *Yikes! What is the value of G ?*

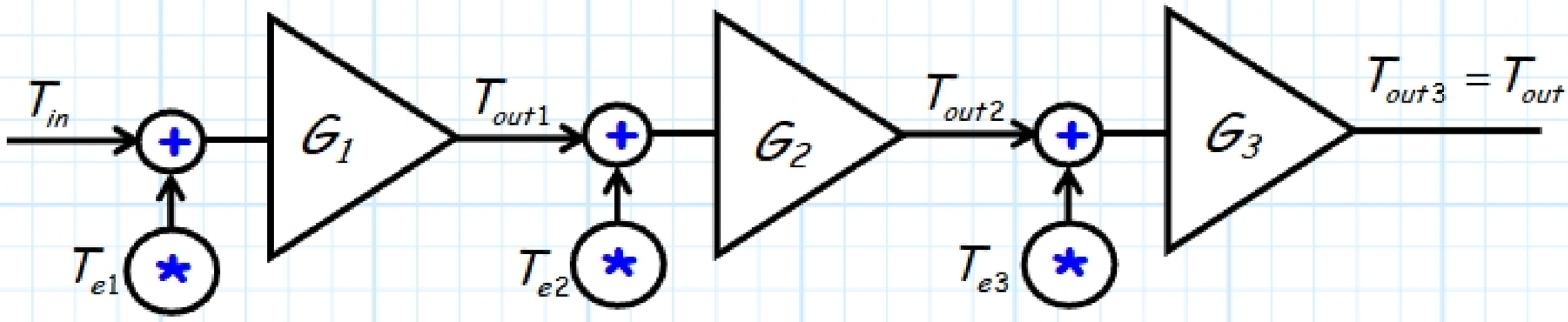
**A:** The value *G* is the **total system gain**; in other words, the overall gain of the three cascaded devices. This gain is particularly easy to determine, as is it simply the **product** of the three gains:

$$G = G_1 G_2 G_3$$

Now for the **hard part**! To determine the value of $T_{out}$, we must use our **equivalent noise model** that we studied earlier:



Thus, we cascade three **models**, one for each amplifier:




We can **observe** our model and note three things:

$$T_{out1} = G_1 (T_{in} + T_{e1})$$

$$T_{out2} = G_1 (T_{out1} + T_{e1})$$

$$T_{out3} = G_1 (T_{out2} + T_{e1})$$

**Combining** these three equations, we find:

$$T_{out3} = G_1 G_2 G_3 (T_{in} + T_{e1}) + G_2 G_3 (T_{e2}) + G_3 (T_{e3})$$

a result that is likewise **evident** from the model.