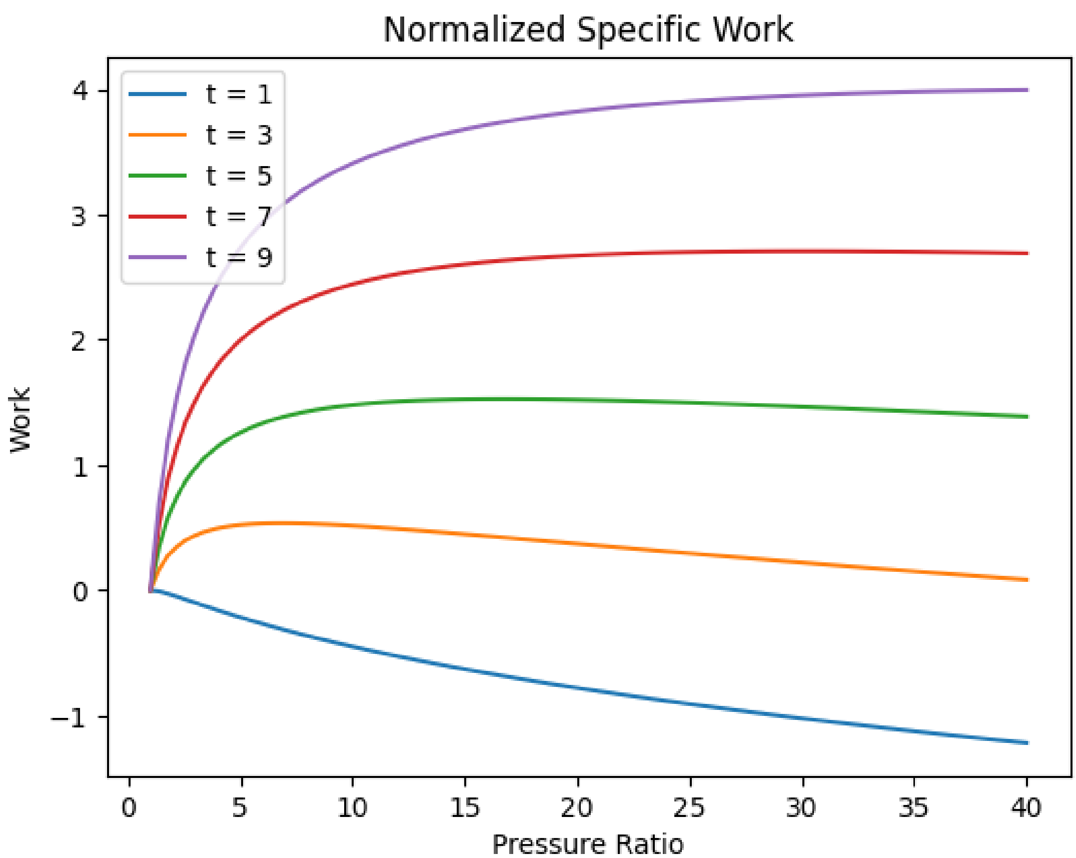
Aero 417 **Name:** **Benjamin Tollison**

1. Create a graphic in a spreadsheet, showing the variaon of the normalized specific work vs pressure ratio (r) for different t values (1, 2, 3, 4, and 5). Explain the behavior of the curves based on the technological level of metals. Use: $\gamma = 1.4$ (air).

$$\frac{W_L}{c_p T_{t1}} = t\left[1 - \frac{1}{r^{\frac{\gamma-1}{\gamma}}}\right] - \left[r^{\frac{\gamma-1}{\gamma}} - 1\right]$$



The higher temperature ratio of combustion to compressor inlet demand a higher pressure ratio across both the compressor and turbine. Based off of the current compression ratio on modern jet having an overall pressure ratio between 40-55. That it is possible to have an engine with the combustor being 9 times hotter than the inlet temperature in order to get the maximum specific net work out of the engine. Then that would mean that engine would be using a tungsten alloy for the combustor and surrounding areas. Which is unlikely, because that would be too heavy. It is more likely that modern engines are using titanium alloys with a pressure ratio and temperature ratio lower at sea level and increasing the temperature and pressure ratios at cruise.

2. About the text: for a Brayton Cycle, the maximum normalized specific work is obtained when $T_2 = T_4$ (compressor outlet temperature = turbine outlet temperature). Is this true or false?

$$\frac{W_L}{c_p T_{t1}} = t\left[1 - \frac{1}{r^{\frac{\gamma-1}{\gamma}}}\right] - \left[r^{\frac{\gamma-1}{\gamma}} - 1\right] \tag{1}$$

$$\text{Where: } t = \frac{T_{t3}}{T_{t1}}, r^{\frac{\gamma-1}{\gamma}} = \frac{T_{t2}}{T_{t1}} = \frac{T_{t3}}{T_{t4}}$$

$$\frac{W_L}{c_p T_{t1}} = \frac{T_{t3}}{T_{t1}}\left[1 - \frac{T_{t1}}{T_{t2}}\right] - \left[\frac{T_{t2}}{T_{t1}} - 1\right] \tag{2}$$

$$\frac{\partial}{\partial T_{t2}}\left(\frac{W_L}{c_p T_{t1}}\right) = 0|_{W_L=\max}$$

$$\frac{\partial}{\partial T_{t2}}\left(\frac{W_L}{c_p T_{t1}}\right) = \frac{T_{t3}}{T_{t1}}\frac{T_{t1}}{T_{t2}^2} - \frac{1}{T_{t1}}$$

$$\frac{T_{t3}}{T_{t1}}\frac{T_{t1}}{T_{t2}^2} = \frac{1}{T_{t1}}$$

$$T_{t2}^2 = T_{t1}T_{t3}$$

$$T_{t2} = \sqrt{T_{t1}T_{t3}} \tag{3}$$

$$T_{t2} = \sqrt{T_{t1}T_{t3}}\left(\frac{\sqrt{T_{t1}T_{t3}}}{\sqrt{T_{t1}T_{t3}}}\right)$$

$$T_{t2} = \frac{T_{t1}T_{t3}}{\sqrt{T_{t1}T_{t3}}}$$

$$T_{t2} = \frac{T_{t1}T_{t3}}{T_{t2}}$$

Where $\frac{T_{t1}}{T_{t2}} = \frac{T_{t3}}{T_{t4}}$ in an ideal Brayton cycle

$$T_{t2} = \frac{T_{t4}}{T_{t3}}T_{t3}$$

$$\therefore T_{t2} = T_{t4} = \sqrt{T_{t1}T_{t3}} \tag{4}$$

Making it true that at max work $T_{t2} = T_{t4}$