Thermodynamic Scale of temperature or absolute scale of temperature

- Efficiency of reversible engine is independent of substance.
- η only depends upon the two-temperature between which engine is working
- Lord Kelvin used this property and defined an Absolute Scale of temperature

Let us imagine that a reversible engine is working between two temp θ_1 and θ_2

$$\eta_R = \frac{Q_1 - Q_2}{Q_1} = f(\theta_1, \theta_2)$$

$$\frac{Q_1}{Q_2} = \frac{1}{1-\eta_R} = \frac{1}{1-f(\theta_1,\theta_2)} = F(\theta_1,\theta_2)$$

Now let us now consider engine is working between θ_2 and θ_3

$$\frac{Q_2}{Q_3} = F(\theta_2, \theta_3)$$

Similarly if it is working between θ_1 and θ_3

$$\frac{Q_1}{Q_3} = F(\theta_1 \theta_3)$$

But we know

$$\frac{Q_1}{Q_2} \times \frac{Q_2}{Q_3} = \frac{Q_1}{Q_3}$$

$$\boxed{F(\theta_1 \theta_3) = F(\theta_1 \theta_2) \times F(\theta_2 \theta_3)}$$

taking log on both the sides and differentiating with respect to θ_1 and θ_3

$$\frac{\partial^2 \ln[F(\theta_1, \theta_3)]}{\partial\theta_1\, \partial\theta_3} = 0 \qquad \text{——— (A)}$$

Now Integrating equation (A) w.r.t. θ_1 and θ_3

$$\ln F(\theta_1, \theta_3) = f_1(\theta_1) + f_3(\theta_3)$$

where $f_1(\theta_1)$ and $f_3(\theta_3)$ are arbitrary function of θ_1 and θ_3.

$$F(\theta_1, \theta_3) = e^{f_1(\theta_1)}\, e^{f_3(\theta_3)} = \psi(\theta_1)\, \phi(\theta_3)$$

So we will have.

$$\psi(\theta_1)\,\phi(\theta_2) \cdot \psi(\theta_2)\,\phi(\theta_3) = \psi(\theta_1)\,\phi(\theta_3)$$

$$\phi(\theta_2) = 1/\psi(\theta_2)$$

$$F(\theta_1 \theta_2) = \psi(\theta_1)\,\phi(\theta_2) = \frac{\psi(\theta_1)}{\psi(\theta_2)}$$

$$F(\theta_2 \theta_3) = \text{- - - -} \quad \frac{\psi(\theta_2)}{\psi(\theta_3)}$$

$$F(\theta_1 \theta_3) \quad \frac{\psi(\theta_1)}{\psi(\theta_3)}.$$

What is 'ψ' ?

It is any function of θ_1 and

Lord Kelvin argued that it can be given as an empirical temperature

$$\boxed{T = A\psi(\theta)}$$

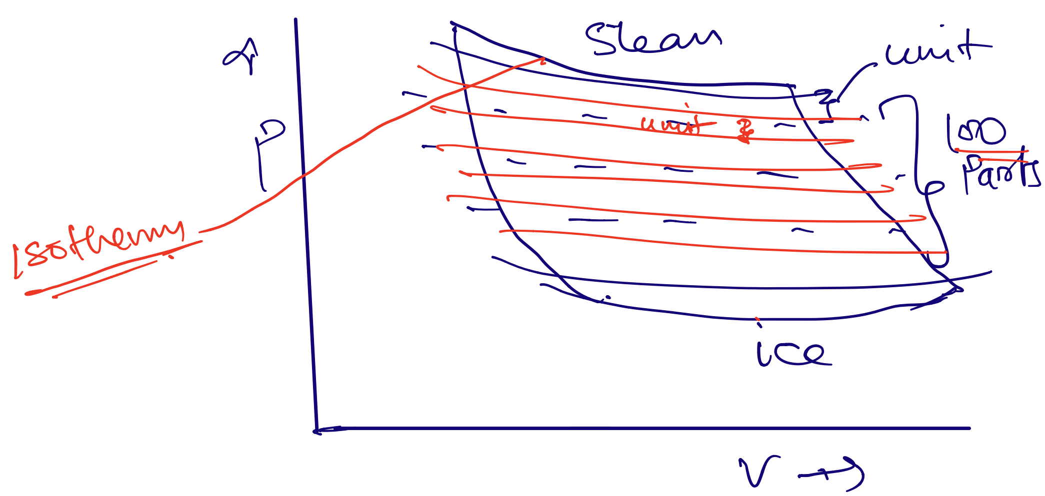
Where A = arbitrary constant.

So we can have $\boxed{\dfrac{Q_1}{Q_2} = \dfrac{T_1}{T_2}}$

and so the temperature is defined by this

Zero : is the temperature of the sink where the rejected heat Q_2 is zero.

Unit: to define the unit: carnot engine is allowed to work between ice and steam temperature



we divide this curve into 100 parts and in this way we get the unit of the Absolute scale.