Problem # 2

Given: A GPHS that operates between 1270 °K and 566 °K, producing 290 W_e at 30 Volts from SiGe thermocouples and a PuO_2 source, calculate;

A.) The open circuit voltage /couple

B.) The Figure of Merit, Z

C.) The optimum resistance ratio

D.) Number of TE elements needed if all the TE are in series.

E.) The material efficiency

F.) The Carnot efficiency

G.) The overall efficiency

Property	p-SiGe	n-SiGe
Seebeck coeff., μV/°K	300	-250
Resistivity, μW-m	27	18
Thermal Conductivity Watt/m°K	5.5	4.8
Figure of Merit, Z x 10^3	0.61	0.72

Open Circuit Voltage

$\Delta V = \alpha^* \bullet (\Delta T)$

$= (|300| + |250|) \bullet 10^{-6} \bullet (1270-566)$

$= 0.387$ Volt/couple

Optimum FOM

$$Z = \frac{\left(|\alpha_n| + |\alpha_p|\right)^2}{\left[\sqrt{(k\rho)_p} + \sqrt{(k\rho)_n}\right]^2}$$

$Z = 6.55 \bullet 10^{-4}$

Optimum Resistance Ratio

$$m_{opt} = \sqrt{1 + Z\overline{T}_m} = \left(\frac{R_L}{R_p + R_n}\right)$$

$$m_{opt} = 1.27$$

# of TE Couples Needed

If the drop is across the circuit, it takes 30/0.387 = 78. Actually, the RTG uses a series/parallel array,

Material Efficiency

$$\eta_{mat} = \left(\frac{m_{opt} - 1}{m_{opt} + \left(\frac{T_C}{T_H} \right)} \right)$$

$$=15.7\ \%$$

Carnot Efficiency

$$\eta_C = \left(\frac{1270 - 566}{1270} \right)$$

$$= 55.4\ \%$$

Overall Efficiency

$$\eta = \eta_{mat} \bullet \eta_C$$

$$=0.157 \bullet 0.554$$

$$= 8.7\ \%$$