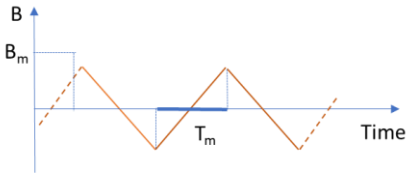
Problem 1 (4 points)

A multifilamentary conductor of diameter d = 0.6 mm, twist pitch L = 10 mm and effective resistivity of the copper matrix of ρ_{eff} = 6 x 10 $^{-10}$ Ohm is placed in a transverse ac magnetic field that oscillates linearly with frequency f = 1 Hz and amplitude B_m = 1 T

1. *Estimate net amount of heat generated by coupling losses in this conductor per one twist pitch length in one field cycle. (2 pts)*



2. *Considering this conductor to be a uniformly-superconducting cylinder for which the full penetration field $B_p = B_m$, calculate the amount of heat generated by hysteretic losses per twist pitch length per cycle (2 pts)*

Problem 2 (3 points)

A ReBCO tape conductor with the critical current I_c was slit along its length in two geometrically-identical portions while the tape ends remained unmodified, as shown:

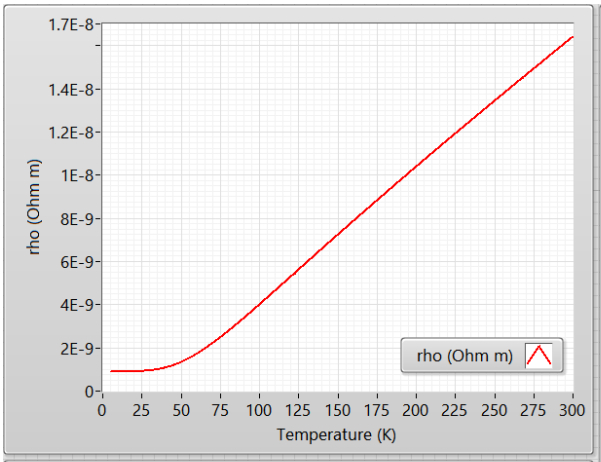
Due to an intrinsic inhomogeneity of the ReBCO conductor, dc critical currents of the straited parts are I_{cA} = 0.4 I_c and I_{cB} = 0.6 I_c respectively.

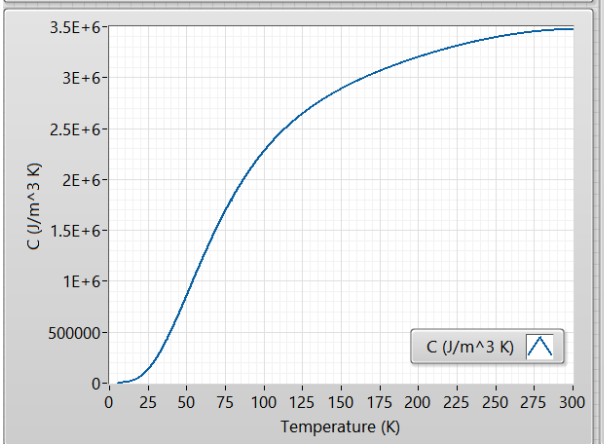
Ac current with amplitude $I_0 \ll I_c$ was applied to the tape terminals. Assuming ac loss in the striated portion is the only source of dissipation in this system and neglecting all inductances, estimate the expected ratio of I_A/I_B in this sample.

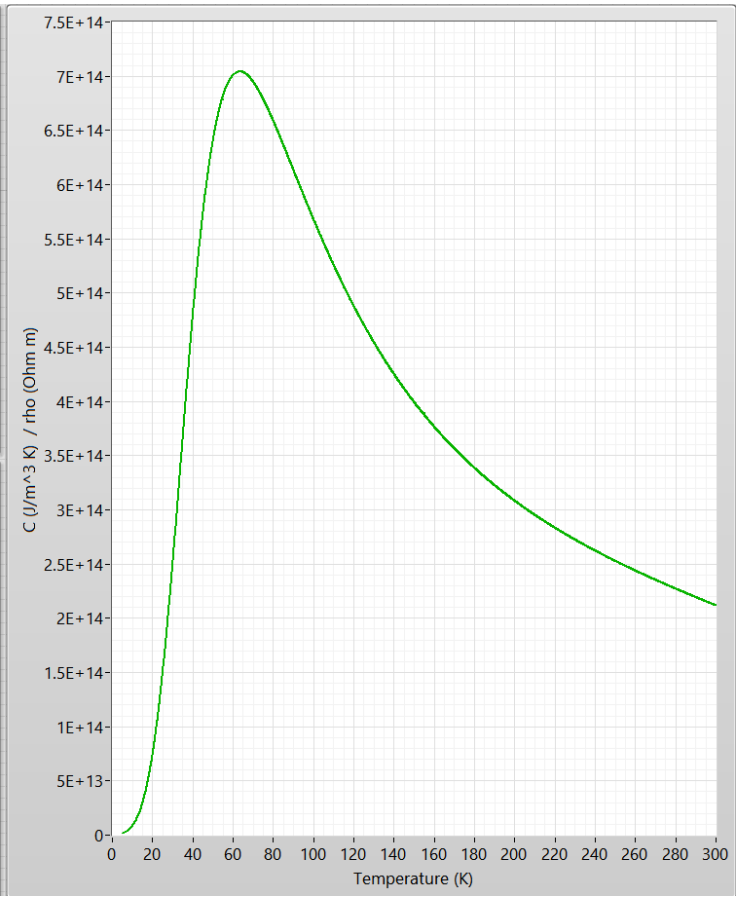
Hint: consider an equivalent circuit where two Ohmic resistors of some "effective" value generate heat under applied dc transport current. What would be the values of those "effective" resistors? How the applied current will be distributing between them?

Problem 3 (3 points)

In the graphs below resistivity of copper ρ (Ωm), volumetric specific heat C $\left(\frac{J}{m^3\,K}\right)$, and their ratio C/ρ are plotted as function of temperature. Using these plot(s) calculate the amount of time needed for a quenching strand of composite Nb_3Sn conductor with diameter d = 0.6 mm and copper/superconductor ratio r = 0.55 to reach temperature of 60 K while carrying constant current I = 300 A. Specific heat of Nb_3Sn can be ignored in this estimate, conditions are adiabatic.


rho (Ohm m)
1.7E-8
1.4E-8
1.2E-8
1E-8
8E-9
6E-9
4E-9
2E-9
0
0 25 50 75 100 125 150 175 200 225 250 275 300
Temperature (K)
rho (Ohm m)


C (J/m^3 K)
3.5E+6
3E+6
2.5E+6
2E+6
1.5E+6
1E+6
500000
0
0 25 50 75 100 125 150 175 200 225 250 275 300
Temperature (K)
C (J/m^3 K)


C (J/m^3 K) / rho (Ohm m)
7.5E+14
7E+14
6.5E+14
6E+14
5.5E+14
5E+14
4.5E+14
4E+14
3.5E+14
3E+14
2.5E+14
2E+14
1.5E+14
1E+14
5E+13
0
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Temperature (K)