Task 22

1. The current in the strip

$$I = nevab,$$

where v is the velocity of electrons, $a = 2$ cm is the width, b is the thickness of the strip. The Hall voltage is

$$V = Bva = \frac{BI}{neb},$$

which implies

$$b = \frac{BI}{neV} = 5.30 \cdot 10^{-7} \text{ m},$$

which corresponds to green (RGB $94, 255, 0$)[1].

2. The internal difference is that the incandescent lamp is hot and the gas lamp isn't. The first one has a continuous Planck spectrum of a hot (black)body, the second one has a line spectrum of the sodium or mercury (or of whatever is inside) atoms. As it can be seen, hot lamps produce "hot" light which is natural and similar to the sun radiation. The cold lamps produce monochrome (sodium, mercury) or "cold" light (fluorescent layers) which is typically equally distributed over the visible frequency range.

3. Assuming the temperature dependence of the RTD's resistance to be $r = r_0 + \alpha t$, where t is the Celsius temperature. Then, as the bridge is balanced at 0°C, the resistance is $r_0 = 25\,\Omega$. At the unknown temperature the RTD's resistance is $r = 37\,\Omega$, so the temperature

$$t = \frac{r - r_0}{\alpha} = 3057°\text{C}.$$

4. If the voltage across the lead is given by $\Delta V = -S\Delta T$ with natural signs, then the change of the voltage for two leads is

$$\delta V = (S_1 - S_2)\delta T.$$

For a numeric calculation a value of S for chrome is necessary.

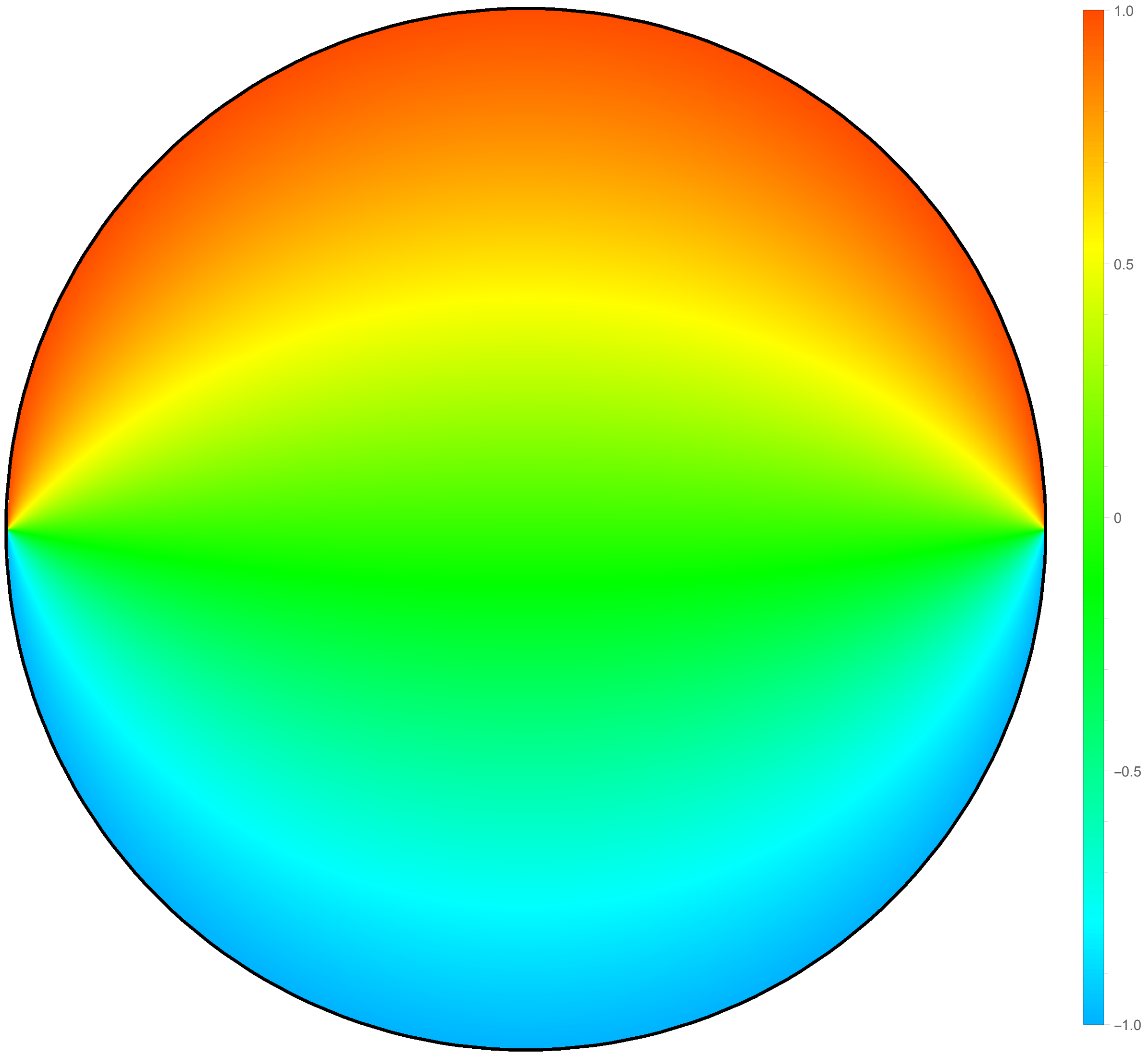
[1] According to `http://academo.org/demos/wavelength-to-colour-relationship/`

Task 23

1. The potential inside (maybe, also outside) the cylinder is given by

$$\phi(\rho,\varphi)=\frac{4}{\pi}\sum_{m=0}^{\infty}\frac{1}{2m+1}\rho^{2m+1}\sin(2m+1)\varphi=\frac{2i}{\pi}\left(\operatorname{arcth}\rho e^{-i\varphi}-\operatorname{arcth}\rho e^{i\varphi}\right),$$

where ρ and ϕ are dimensionless (normalized) variables and $\operatorname{arcth}x$ is the inverse hyperbolic tangent function. The plot of this dependence is given below.



2. Similar to task 22.2.

3. If the current is i, then the rotating moment due to the Ampere force is

$$M=\frac{1}{2}BiR^2=J\dot{\omega}.$$

Then the angular velocity depends on the total charge q which passed through the system as

$$\omega=\frac{BqR^2}{2J}.$$

Also, due to energy conservation,

$$qV = \frac{J\omega^2}{2} + \frac{Li^2}{2},$$

which implies

$$\frac{L}{2}\left(\frac{2J}{BR^2}\right)^2 \dot{\omega}^2 = \frac{2J}{BR^2}V\omega - \frac{J\omega^2}{2}.$$

The solution of this equation is

$$\omega(t) = \frac{4V}{BR^2}\sin^2\left(\frac{BR^2}{4J}\sqrt{\frac{J}{L}}t\right) = \frac{2V}{BR^2}\left(1-\cos\left(\frac{BR^2}{2J}\sqrt{\frac{J}{L}}t\right)\right).$$

The corresponding expression for current is

$$i(t) = \frac{2V}{BR^2}\sqrt{\frac{J}{L}}\sin\left(\frac{BR^2}{2J}\sqrt{\frac{J}{L}}t\right).$$

4. The bulk modulus K is defined as

$$K = -V\frac{dP}{dV}.$$

Integration gives

$$\ln\frac{V_0}{V} = \frac{p}{K},$$

which yields

$$p = K\ln\frac{V_0}{V} = 2\cdot 10^8 \text{ Pa}.$$