Investigating Thermal and Electrical Properties of Light Bulb

Studio 4
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Theory Of Experiment

- An ideal black body should follow the Stefan Boltzmann law for its radiative power ,stated as

$$P = \varepsilon\sigma A T^4$$

- The theoretical model proposed for the relationship between temperature of filament and resistance has been assumed to be non linear:

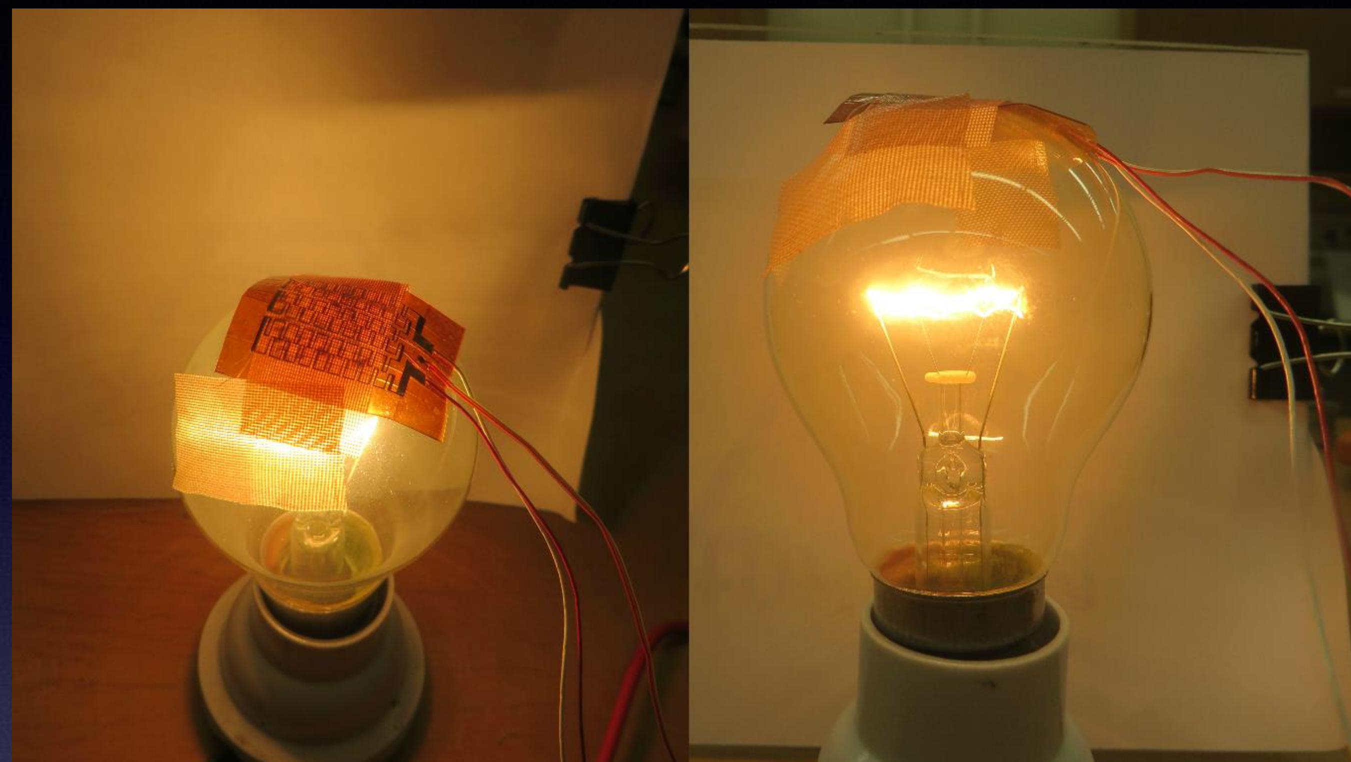
$$T = T^{O} \, (R/R°)^{\gamma}$$

- An ideal black body has emissivity 1 and it is independent of temperature.

For a glass bulb,the power received at the surface is a fraction of the power emitted by filament.This fraction remains constant with temperature.

Temperature resistance constant, R/Rº=Resistance to Room temperature, T^{O}=Room Temperature

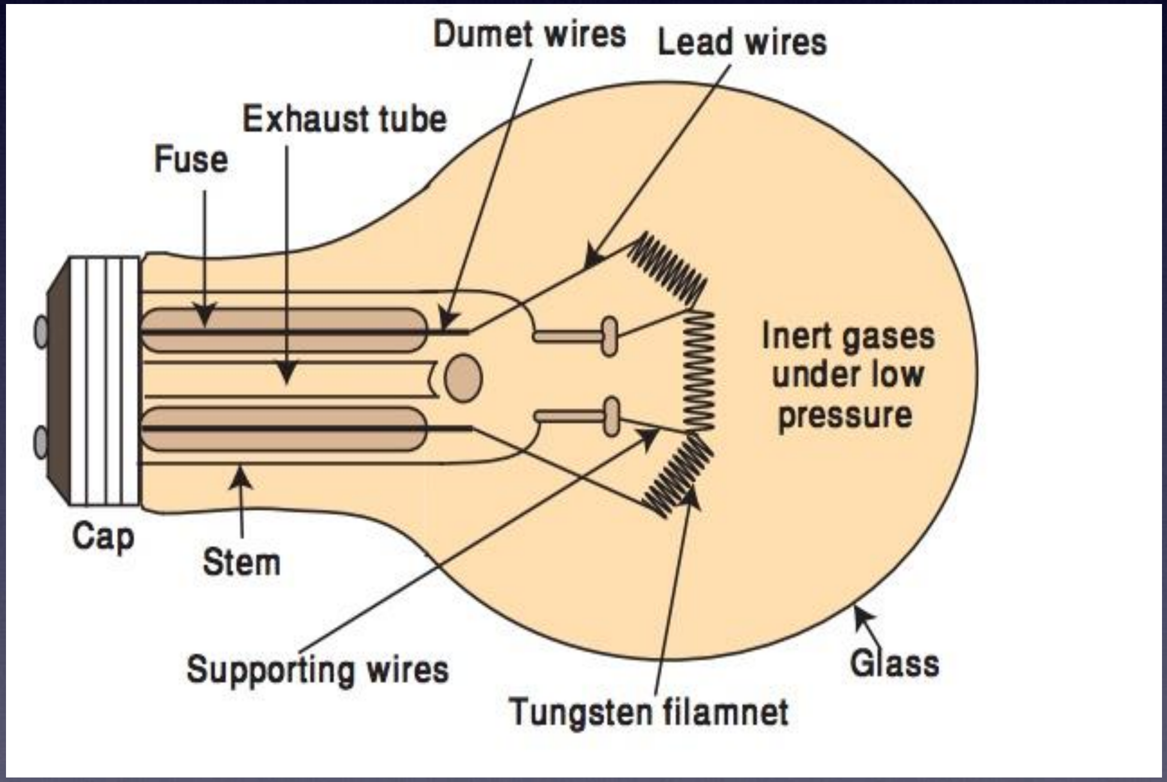
Experimental Setup



Experimental procedure

- 60 Watt incandescent light bulb used, and its resistan ce is measured electrically(as the ratio of voltage to cu rrent). Using our Temperature-resistance model, corre sponding temperatures were measured. (good method for temperatures below 3000 K).
- A surface thermopile(HFS-3 sensor) was used to mea sure the intensity of energy received at the bulb’s surf ace. It registers readings in millivolts, which can be cal ibrated to find the value of intensity at surface for varyi ng values of input power.
- A surface Type K thermocouple was used to measure the temperature of the light bulb at the surface of the b ulb. This too was noted for varying voltages.

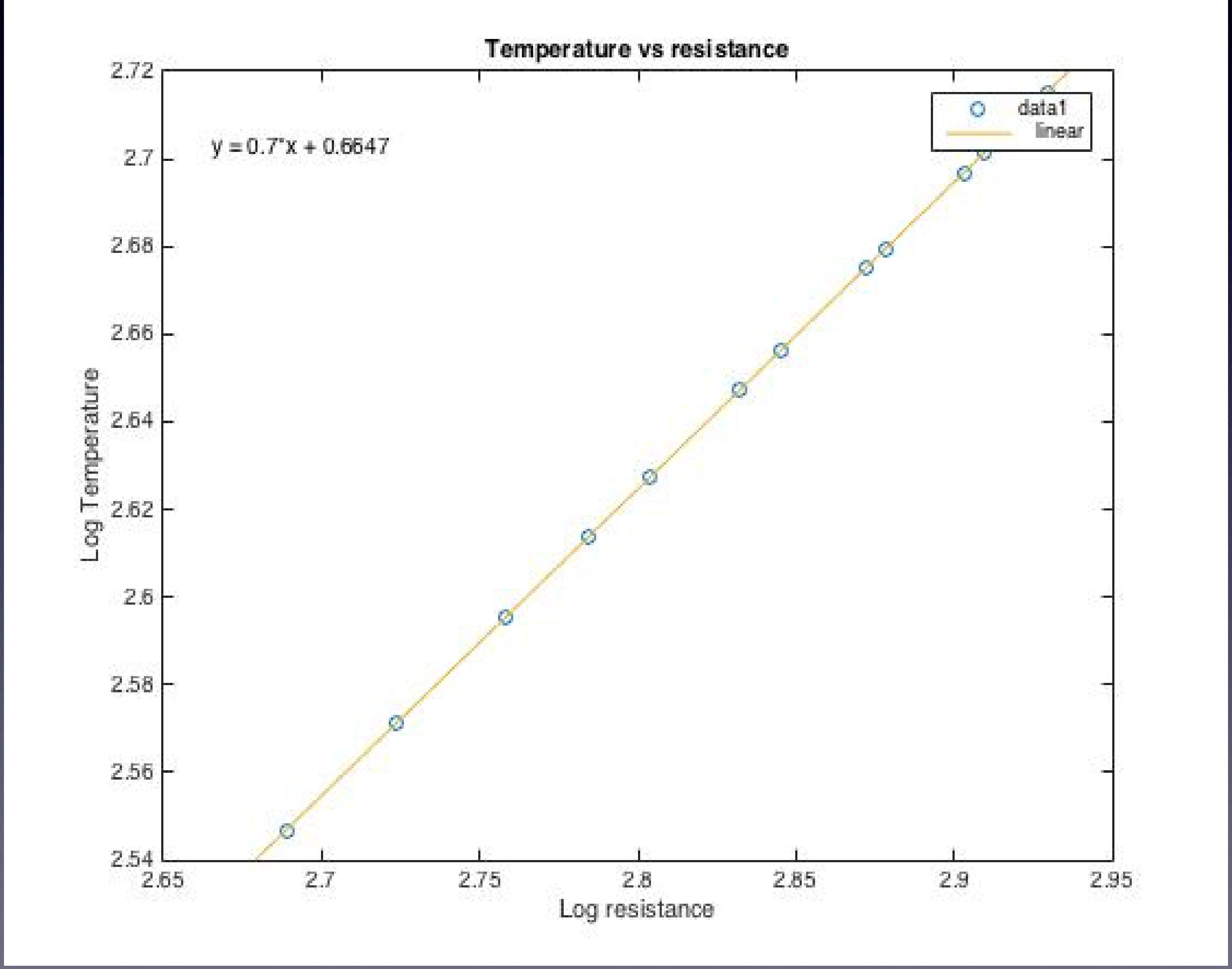
- Since we have considered bulb as a black body,we have assumed that the emissivity is 1 and remains constant regardless of any change.
- Losses through conduction and convection are also assumed to be negligible.



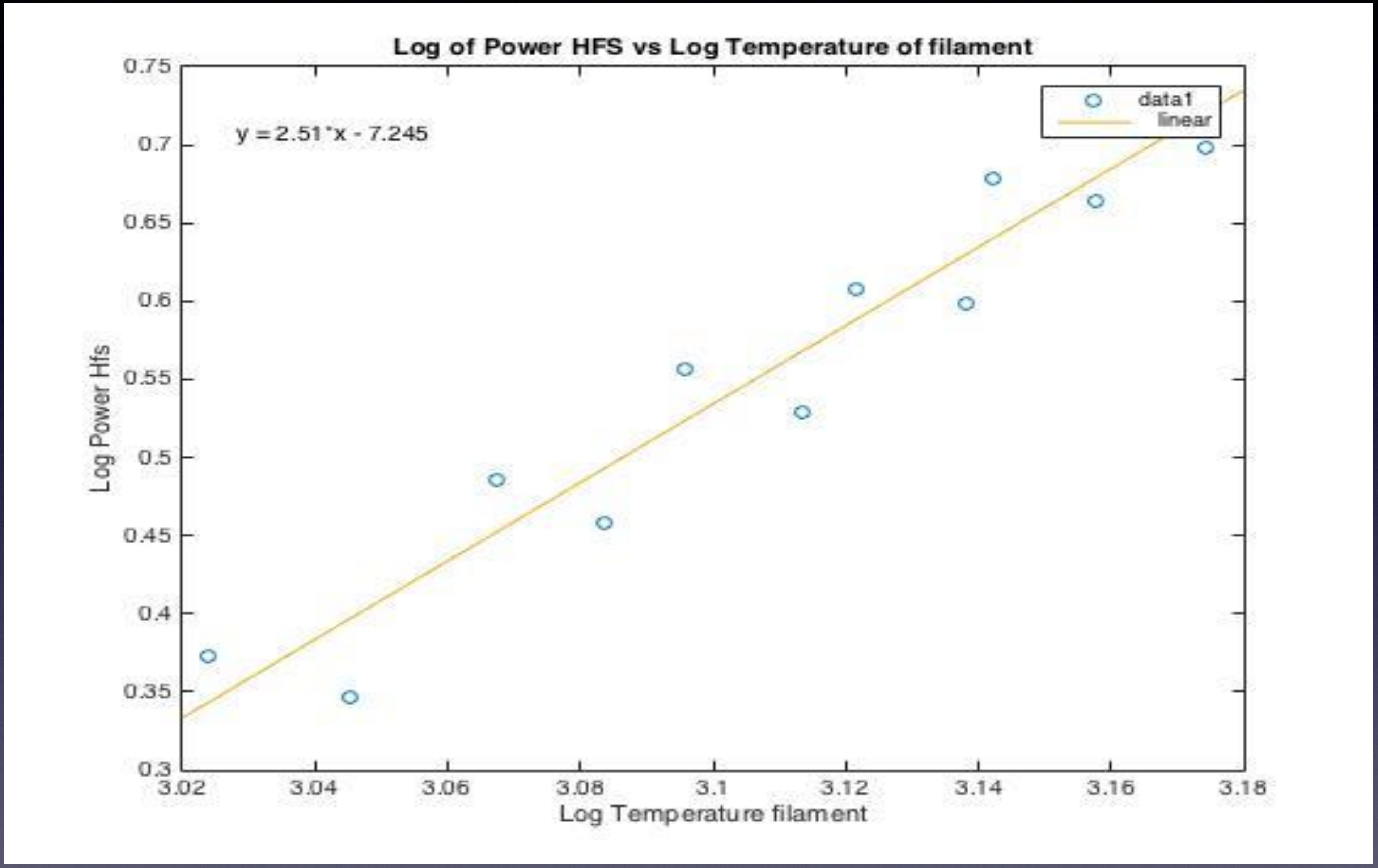
- All of instrumental errors were accounted for in final u ncertainty analysis.

Experimental Deductions

- We found the temperature of the filament by electrical methods which varies with different values of resistance.



$$P' = \propto P$$



$$\log P' = 4 \log T + \log(\sigma \varepsilon A \propto)$$

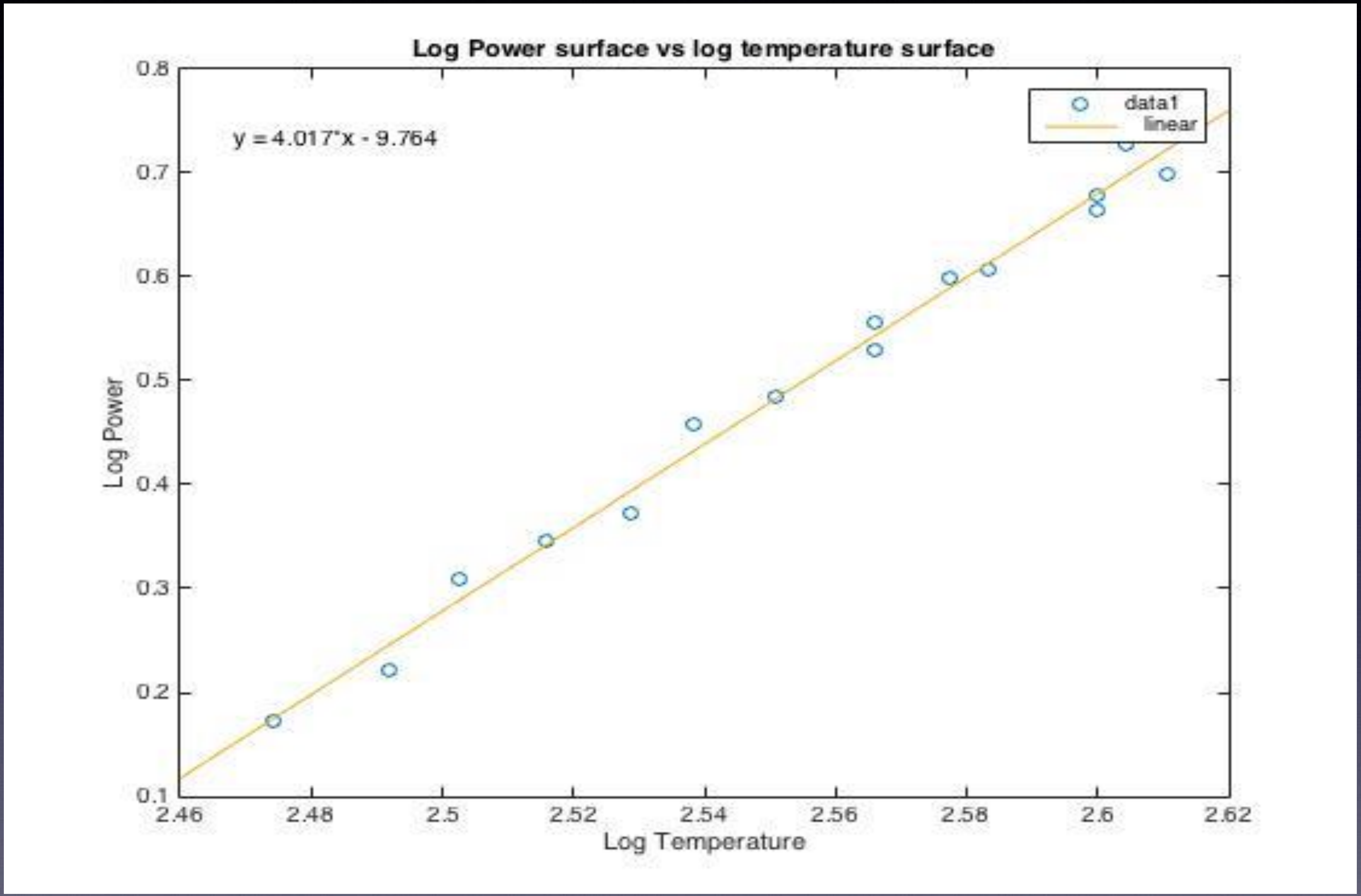
- These results show that the assumptions made are not completely accurate.

- In reality,the measurement is very complex as there are a number of factors affecting the emission of radiation,and are given as follows:

- The losses through conduction and convection are not negligible as the filament is not isolated .Therefore, conduction through lead wires connecting filament is significant .

- The emissivity,assumed as 1,is actually not constant but rather it is a function of temperature. The emissivity of the bulb must include both the emissivity of tungsten(0.4) and the glass bulb surface(0.95),therefore the initial assumption of taking emissivity to be 1 is not correct.Emissivity for the case of a bulb is a complex discussion which is dependent on purity of tungsten sample,the geometry of the filament as well as that of the glass bulb.

- We extended our experiment to measure the heat flux at surface and the corresponding temperatures, only at surface of the light bulb.



$$\log P' = 4logT' + \log(\sigma \varepsilon A)$$

Results

- We found that the temperature of the glass bulb fits our th eoretical model of a non-linear increase to a considerable extent

- From these results, it can be concluded that the complete bulb behaves more like a gray body, due to the changes in emissivity and power losses.

$$P = k(T - T°) + C(T)\frac{dT}{dt} + \sigma\varepsilon(T)AT^4$$

- The bulb was not evacuated which could have led to power losses through convection.

- The results of power radiation through bulb surface are closer to the value predicted by Stefan Boltzmann law, suggesting that the surface of bulb exhibits properties close to those of an ideal black body. And that the behavior of the filament and the surface are distinct from each other.

Further investigation

- Since this is a very complex investigation , therefore,it has huge potential for improvement.
- Emissivity itself is a very complex phenomenon, which needs cumbersome investigation. The various factors affecting it like geometry, heat capacity etc.can be thoroughly investigated.This will also be of commercial value as higher emissivities will lead to more efficient bulbs.
- The behaviour of bulbs of different wattages can also be investigated.The bulb used in this experiment was 60W.
- As an extension,the spectral properties of light bulb can also be investigated in which the wavelength spectra of light emitted by bulb can be explored.