Journal of Physics Special Topics
An undergraduate physics journal

A2_3 This Desk is on Fire

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December 7, 2020

Abstract

This paper looks at the wasted heat energy released from laptop chargers and calculates how many would be required to burn a wooden desk. We calculated that in one hour it would require a minimum of 4.1×10^4 chargers to burn a desk. Instead, with 50 chargers fitting around the desk and energy loss to surroundings, it would take 23 hours for it to burn.

Introduction

In modern society everything is connected to electricity. Plug sockets can be found in every household in every room to power a multitude of appliances. Although, every electrical appliance and related chargers emit wasted energy in the form of heat. Placing large quantities of heated power supplies together can lead to substances nearby burning or being set on fire.

In this paper we investigate how much energy is wasted through laptop chargers to thermal energy. From this we find the number of chargers needed to be turned on in one location, which would be required to burn a desk. Compared with this, we calculated how long it would take for a set amount of chargers to burn the desk, including heat loss to the surroundings.

Theory

To begin the excess heat energy of one charger was required. Using equation 1, the total energy E_{tot} used by the charger could be calculated over a given time t, given the total power P used by the charger.

$$E_{tot} = Pt \tag{1}$$

To enable an object to burn, the object must be at a sufficiently high temperature and hence a large amount of energy. The energy Q required to get the object to this temperature is given by,

$$Q = mc\Delta T \tag{2}$$

where m is the mass of the desk, c is the specific heat capacity of the object and ΔT is the change in temperature of the desk.

The heat loss to the surroundings q, can be calculated in equation 3 from Newton's law of cooling,

$$q = hA\Delta T_{med} \tag{3}$$

where h is the heat transfer coefficient, A is the cross-sectional area, and ΔT_{med} is the change in temperature between the two mediums.

Discussion

We started this process by taking the scenario of a laptop charger directly underneath a wooden desk in a working home. Using a laptop charger working at a power of 60 W [1], we calculated the energy usage of a singular charger in one hour was 3600 J by using equation 1. The majority of this power would be used to charge the laptop as electrical energy. However by assuming the

laptop charger has a 83.25% efficiency [2], only 603 J would be wasted as thermal energy.

Next, in order to burn the desk, it would need to reach a temperature of 233°C [3], at which point the wood could spontaneously combust, from a room temperature of 25°C. The energy for this to occur was calculated using equation 2. The mass of the desk was 50 kg [4] and specific heat capacity of oak was 2380 $Jkg^{-1}K^{-1}$ [5]. Therefore this required a total energy of 2.5×10^7 J to heat the desk.

The number of chargers needed was found by dividing the total energy required by the thermal energy of a singular laptop charger. This would hence require a minimum of 4.1×10^4 chargers to get the total energy to burn the desk. This large amount of chargers would cover the entire desk and take up the entire room. Based on this there would be little heat loss to the surroundings.

To change this, the time was measured for a set amount of chargers to heat up the desk. Across the back of the desk of an area of 0.5 m^2, approximately 50 chargers ($5\times5\times20$ cm) would fit against the desk. The maximum temperature the chargers would reach was 65°C [2]. Based on equation 2, the energy loss to heat up the air was 200 Js^{-1} where the heat transfer coefficient of air is 10 $Wm^{-2}K^{-1}$ [6]. Taking this from the wasted thermal energy of each charger and based on the required energy to heat the desk to burn, it would take approximately 23 hours for it to burn.

Conclusion

In conclusion, it was found that it would require a minimum of 4.1×10^4 laptop chargers to heat a 50 kg wooden desk to get it to a high enough temperature to set it on fire.

However, this value is too large to fit around a singular desk. Hence fitting 50 chargers around a section of the desk, would release 200 Js^{-1} to the surroundings and would require approximately 23 hours for these chargers to heat the desk. This would not account for heat loss through the desk over time.

In this scenario, we assumed the desk would be burned due to the excess heat of the laptop power supplies. In a real situation, this large number of chargers would start a fire due to a overload in current in a single circuit. Hence in this scenario the occurrence of a fire starting from a large current was not incorporated [7].

Therefore it can be concluded that without an exceedingly large amount of electrical chargers, there is little possibility that the excess heat energy emitted will cause damage to nearby surfaces or items.

References

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