Second Murder Mystery

You and your class have rented out a mansion for an end of year celebration. Everyone is having a lot of fun hanging out, playing games, and eating food. Suddenly you all hear a loud scream coming from the upstairs of the mansion. Everyone rushes upstairs and you all see that on their way to the bathroom one of your classmates had discovered a dead body in the hallway outside of the library. The man who has died is the owner of the mansion and no one seems to know who did it. The only thing everyone agrees on is that it must be someone in the class because there was no one else in the mansion. At the time the body was found the entire class is present.

One of your friends comes up with the suggestion that maybe if they knew the time of death you can determine who must be the murderer based on who was most likely to be with the mansion owner at that time.

How would you proceed ?

Another one of your friends has the idea that knowing the temperature of the body would help to figure out the time of his death, so immediately a thermometer is found and the corpse's body temperature is taken. According to these measurements the body was 33.89 degrees Celsius at 6 pm when the body was found. Two hours later the body's temperature is taken again but it is now found to be 30.33 degrees Celsius.

The facts:

- The mansion owner was found in the hallway near the library.
- There is only one pathway in front of the library and it leads to the bathroom.
- The temperature of the body was 33.89 degrees Celsius at 6 pm.
- The temperature of the body was 30.33 degrees Celsius at 8 pm.
- The thermostat was found to be set at 21.11 degrees Celsius.

After much discussion everyone was able to remember the times that they were up in the hall passing by the library to walk to the bathroom.

Make sure you can explain and describe your calculations in English.

Did you know?

An exponential equation such as $e^x = 3$ can be rewritten as the equivalent logarithmic equation $x = \log_e 3$. We often use the special notation ln for the natural logarithm, instead of log_e.

Newton's formula for cooling: $T(t) = T_{env} + (T_0 - T_{env})\, e^{-kt}$

Where:

- $T(t)$ is the temperature of the body at time t,
- T_{env} is the temperature of the surrounding environment,
- T_0 is the initial temperature of the body (look up average body temperature for this),
- t is the time after death in hours, and
- k is a constant that can be calculated using the formula $e^{-2k} = \dfrac{T(t+2) - T_{env}}{T(t) - T_{env}}$.

1. Let t represent the time after death that the body was found (in hours). Using this fact, at time t when the body was found, the temperature of the body was 33.89 degrees Fahrenheit. Two hours later, at time $t + 2$, the temperature of the body was 30.33 degrees Fahrenheit. Substitute the values you know and solve for t to find the time that elapsed before the body was found.
2. What time was he killed?