## *Hot Air, Cold Body:*
## *Using Newton's law of cooling to determine time of death*

Use Newton's law of cooling to narrow down the number of suspects by determining when the victim was killed.

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Paramedic report

Date: 2015

Time: 9:45 p.m.

Body temperature: 29.0°C

Notes: Elevator temperature was high; thermostat set at 27°C.

## Activity Materials

- Calculator
- Temperature Probe
- a “potato/body”
- your brain ☺

## Procedure:

**Part 1 – Collecting Data**

1. Look at the paramedic report. Record the temperature of the body and the time the body temperature was measured into the “From the Evidence Report at Crime Scene” section of the Evidence Record on the worksheet. Also, write your findings of the blood spatter at the crime scene under the “Blood Spatter Analysis” section of the crime report (on the back).
2. Obtain a "body" from your teacher.
3. Be sure to hold the Temperature Probe in the air away from heat sources and sunlight. Make sure the tip of the probe is not touching anything warmer or cooler than room temperature (such as your hand). **Record the room temperature (*a)* in the “From the Model” section of your Evidence Record on the student worksheet**.
4. Now insert the Temperature Probe into the “potato/body”. Be sure to not have the probe stick all the way to the middle of the “potato/body”. You want the probe firmly in the middle of the “body”. Think of a medical examiner sticking the temperature stick into a victim’s liver☺.
5. Wait for the temperature sensor to stabilize (takes about one minute). Start data collection. You will collect data for 20 minutes.
6. When data collection is complete, look at the temperature vs. time graph that you have graphed.
   a. Locate the maximum temperature reached by the “potato/body” during the data collection. Record this temperature as the initial temperature *(i)* of the “potato/body” in “From the Model” section of your Evidence Record.
   b. Record the time (in seconds) at which the max temperature occurred. **This is the initial time.**
   c. Locate the minimum temperature reached by the model, and record it in your evidence record as the final temperature (*f)*. Record the time it occurred as the time of minimum model temperature. This is the final time. (This should be the last point on the graph).
   d. Finally, subtract the initial time from the final time to find how long your “potato/body” was cooling. Enter this time in your evidence record as the duration of the temp measurement *(t).*

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**Part 2 – Analyzing the Data**

7. You will now you use your collected data from the "potato/body" to determine time of death at the crime scene. We can use Newton's law of cooling:

Newton's law of cooling is an exponential relationship that states:

**The Newton s Law of Cooling Formula is given by:**

$$T(t) = T_{room} + (T_o - T_{room})e^{-kt}$$

**Where t is the time taken,**
**T(t) is the temperature of the given body at time t,**
**$T_s$ is the surrounding temperature,**
**$T_o$ is the initial temperature of the body,**
**k is the cooling constant.**

*Using the data collected from your "potato/body", you will first need to determine the cooling rate, **k**, and then apply it to the crime scene data to ultimately determine the Time of Death. To do this, you will use the data collected from the model "Potato/Body" (use first table only!).*

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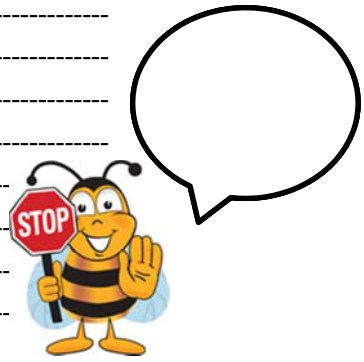

**Part 3 – Applying the Data and Formula to your Dead Body**

8. Now that you know the Cooling Constant (***k)***, you can use it to determine how long the body cooled at the crime scene before the paramedics measured its temperature. To figure this out, you need to solve the cooling equation again, this time for the unknown variable ***t***, (cooling time). *In this case, we assume the body cooled from normal body temperature 37℃*. **Record ALL info in the Evidence Record.**

Time of Death: _____

*Adapted from Texas Instrument Website

10. (IF TIME…)

a.) Find the regression using your calculator. What type of equation would you try to fit to the data?

TYPE OF FIT USED: _____

EQUATION FROM CALCULATOR: _____

b.) Now find the time of death using the calculator's equation. Is it close to yours? What might explain any differences?

*ONCE THE EVIDENCE RECORD IS COMPLETED AND YOU HAVE DETERMINED TIME OF DEATH, PLEASE STAPLE AND SUBMIT TO MS. TOMAS AT THE END OF THE PERIOD!

## EVIDENCE RECORD

**USE WITH PART 2:**

| From the Model ("Potato/Body") | |
|---|---|
| Ambient (room) temperature for model(ºC) | |
| Initial temperature of model (ºC) | |
| Final temperature of model (ºC) | |
| Time of maximum model temperature (s) | |
| Time of minimum model temperature (s) | |
| Duration of model temperature measurement (s) | |
| **Cooling constant, k** | |

**USE WITH PART 3:**

| From the Evidence Report at Crime Scene | |
|---|---|
| Ambient (room) temperature in the elevator (ºC) | |
| Time body temperature was measured | |
| Temperature of living Human Body (initial) | 37º |
| Temperature of body (ºC) (final) | |
| Cooling time, t (s) | |
| Cooling time, t (min) | |
| **Actual Time of Death** | |

OTHER NOTES ABOUT THE DECEASED:

| | |
|---|---|
| **TRAMA TO BODY:** (any wounds, bruises) | **INITIAL APPROX. OF CAUSE OF DEATH:** |
| **BLOOD SPATTER ANALYSIS:** | **ALGOR MORTIS:**<br>Pending calculations |
| **LIVOR MORTIS:** (pooling of blood at the lowest part of the body caused by gravity…you can tell if the body has been moved by this☺) | **RIGOR MORTIS:** Stiffening of the body (used if PMI is 12-24 hours) |

PMI:  Postmortem Interval
Teacher Background on PMI:

PMI:  Postmortem Interval:  Key piece of info in solving a crime.
Can't be determined exactly  - environmental concerns (in heat body can actually warm after death…in cold temps body cool faster).  Amount of clothing or covering, fever, etc also matter.

3 things are looked at by attending forensic pathologist:

1. ALGOR MORTIS:  tendency of a body to cool after death (only used if death is within 12 hours)
2. LIVOR MORTIS:  pooling of blood at the lowest part of the body caused by gravity (you can tell if a body has been moved)
3. RIGOR MORTIS:  Stiffening of the body (used if PMI is 12-24 hours).
   Muscles and joints are relaxed at first
   2-5 hours muscles contract causing stiffness
   Process is complete between 12-24 hours
   Over the next 2-3 days the stiffness disappears

Other methods of estimating PMI:

- Chemical levels (potassium levels in eye fluids and metabolites in the brain).
- Film over the eye
- Stomach contents (takes 2-4 hours to digest a meal)_

Late PMI:

- After 1-2 days has passed, decomposition can begin/skin turns color, insects (forensic entomology)

Notes:

- ✓ Make sure they set LoggerPro to collect data for 1200 seconds!!! Otherwise it will STOP collecting data!!!
- ✓ Have them check on their potatoes on a regular basis…the probe can fall out!
- ✓ Color potato pink/purple for livor mortis and red for the femeral artery gush.
- ✓ Set up crime scene with gush from artery and body moved.
- ✓ Takes more than one day. Maybe have them collect data on day 1 and determine cooling constant and PMI on day 2.