

# TP en Anglais

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L2 Physique  
Cours 2023/24

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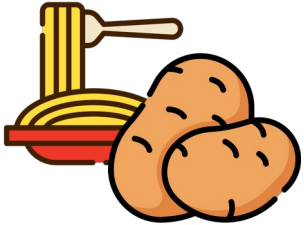
# Organization



English is the official language of science



Groups of two or three people (all 5 tables must be full!)



Two hands-on labs in 2 sessions (physics in the kitchen)

- 3 hours today - heat transfer in potatoes
- 3 hours next week - elasticity of pasta

# Evaluation



40% Participation



60% Scientific poster based on one of the two experiments

- simulation of a scientific conference
  - done in groups
  - delivered by April 2<sup>nd</sup> on Ametice
  - presented **individually** to us + Prof. Anne Laurence Beurtheret
- April 19<sup>th</sup>

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Collect the data and check that you reproduce the results

Session 1:

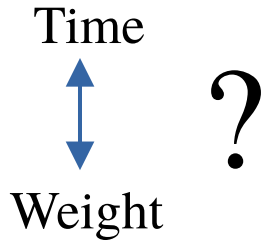
Heat transfer – How long does it  
take to cook a potato?

# Cooking food

## Timetable for Roasting Turkey STUFFED (Fast Oven: Covered – 450° Fahrenheit)

Preheat oven to 450° Fahrenheit. Cook until the bird reaches the correct internal temperature.

Cover bird with aluminum foil before cooking. Remove cover during the last 30 minutes to allow skin to brown.



Ready to Cook Weight (Before Stuffing)	Estimated Cook Time	Internal Temperature
10 – 13 lbs.	2½ – 3 Hours	180 – 185° F
14 – 17 lbs.	3 – 3¼ Hours	180 – 185° F
18 – 21 lbs.	3½ – 4 Hours	180 – 185° F
22 – 25 lbs.	3½ – 3¾ Hours	180 – 185° F
26 – 29 lbs.	3¾ – 4¼ Hours	180 – 185° F
30 – 33 lbs.	4¼ – 4¾ Hours	180 – 185° F
34 – 37 lbs.	5¼ – 5¾ Hours	180 – 185° F

### BARBECUE ROAST LAMB COOKING TIME

Barbecue roast lamb cooking times  
(Internal temperature goal)

Lamb Cut	Barbecue Temp	Rare (60°C)	Medium (65–70°C)	Well Done (75°C)
Lamb round, topside roasts, lamb rump	200°C	20 min per 500g	25 min per 500g	30 min per 500g
Rack of lamb	200°C	20–25 min total (regardless of weight)	30–35 min total (regardless of weight)	40–45 min total (regardless of weight)
Leg or shoulder (bone in), easy-carve leg, shoulder	180°C	25 min per 500g	30 min per 500g	35 min per 500g

# Cooking food

Internal target temperature  $T_c$



Starch gelatinization

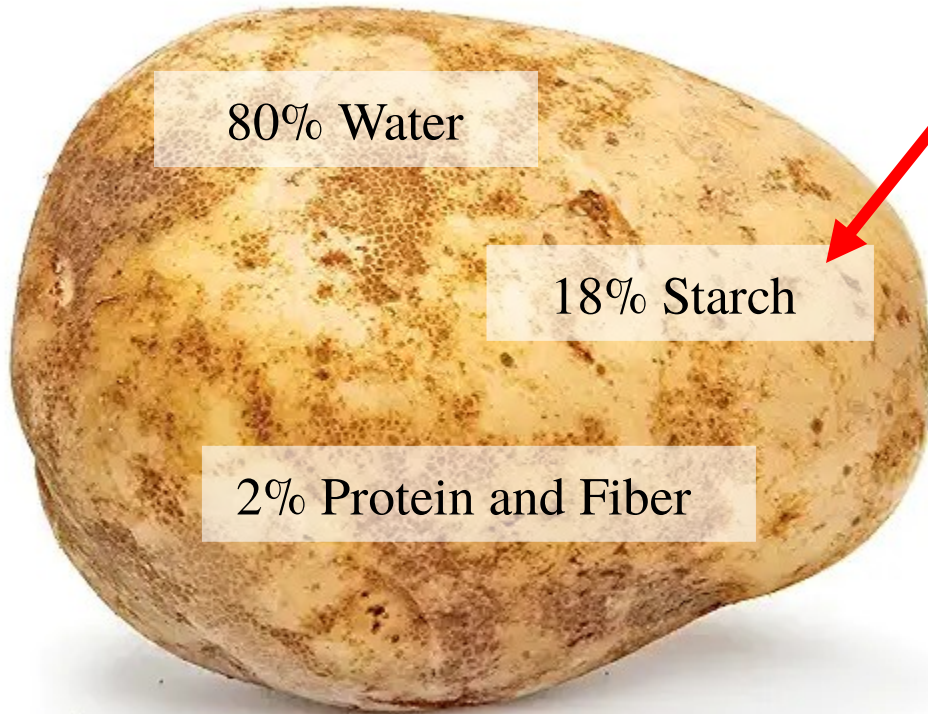


Protein coagulation



Cheese pasteurization

# Cooking potatoes



At 58°C to 66°C starch gelatinizes

- becomes edible
- becomes translucent

Perfect for our goals

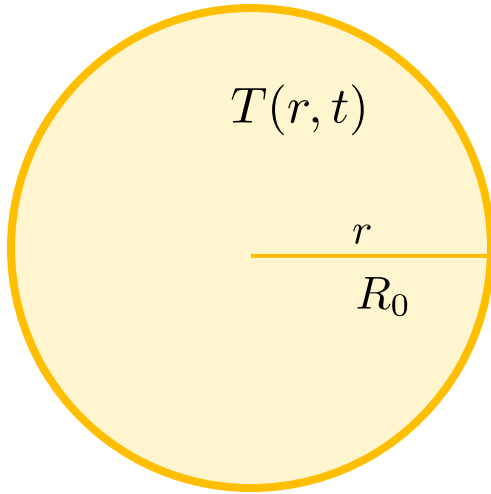
- almost spherical
- cheap
- easy to measure the heat transfer (around 60ish °C)

The potato is cooked when its center reaches 65°C



# Spherical potato model

Spherical potato



Temperature field

Thermal diffusivity

$$\partial_t T(\vec{x}, t) = \kappa \nabla^2 T(\vec{x}, t)$$

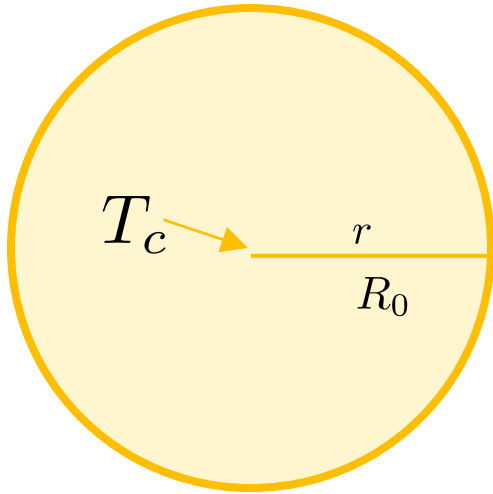
Temperature diffusion equation

Solution for an uniform sphere in a heat bath

$$\frac{T(r, t) - T_w}{T_a - T_w} = 2 \sum_{n=1}^{\infty} (-1)^n \frac{R_0}{n\pi r} \sin\left(\frac{n\pi}{R_0} r\right) e^{-\kappa \left(\frac{n\pi}{R_0}\right)^2 t}$$

# Spherical cooked potato

Spherical potato



$$T(0, t_c) = T_c$$

$$\frac{T_c - T_w}{T_a - T_w} \approx 2e^{-\kappa \frac{\pi^2}{R_0^2} t_c}$$

$$t_c \approx \frac{R_0^2}{\kappa \pi^2} \log \left( \frac{1}{2} \frac{T_a - T_w}{T_c - T_w} \right)$$

$$t_c \approx 70s \left( \frac{R_0}{1cm} \right)^2$$

Cooking time is proportional to size *squared*

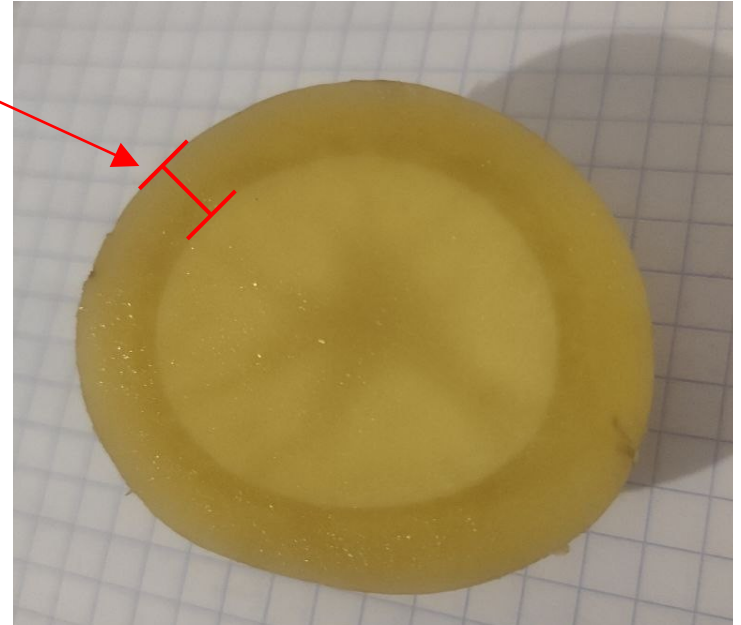
# The experiment

For a given time  $t$  (use your phone's *stopwatch*):

1. Boil one potato for a given amount of time
2. Cut the potato in half
3. Measure with a *caliper* the width  $x$  of the cooked ring of the potato

$$x \propto \sqrt{t}$$

Detailed instructions in  
the experiment file



# Expectation $x \propto \sqrt{t}$

