A bright sun is positioned at the top center of the frame, casting a strong, multi-pointed starburst of light across a clear blue sky. Below the horizon, a vast expanse of water is covered with numerous ice floes of various sizes and shapes. The sun's reflection is visible on the water's surface, creating a shimmering path of light. The overall scene suggests a polar or subpolar environment, likely used to illustrate the effects of global warming on ice melt.

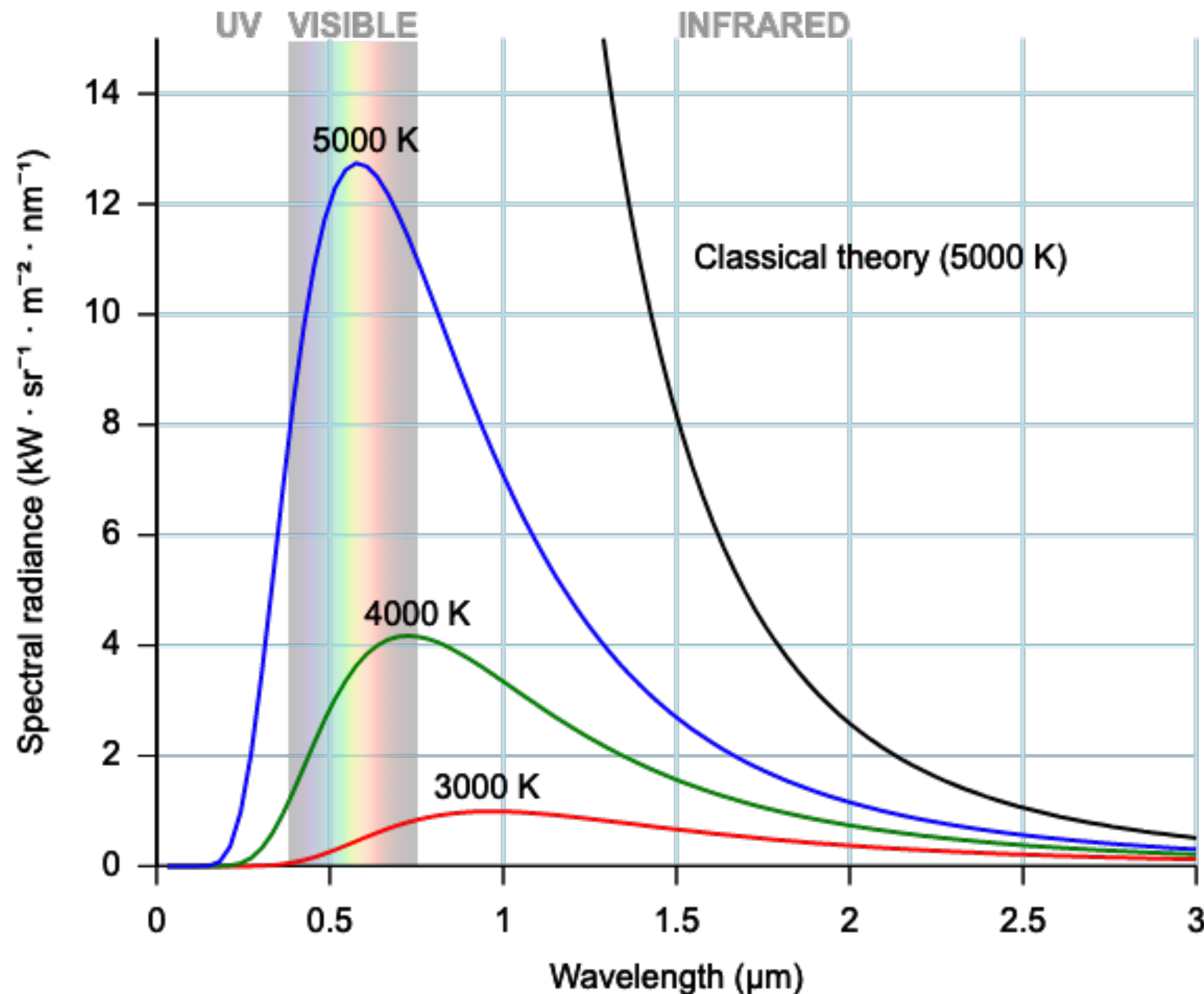
Global Warming

Lecture 3.4

Blackbody Radiation

Blackbody: Blackbodies are perfect emitters and absorbers of electromagnetic radiation

They emit radiation at different wavelengths according to the **Planck Function**



Planck function



**hotter bodies emit
more radiation and
have a peak emission
at a shorter
wavelength**

Who is Planck?

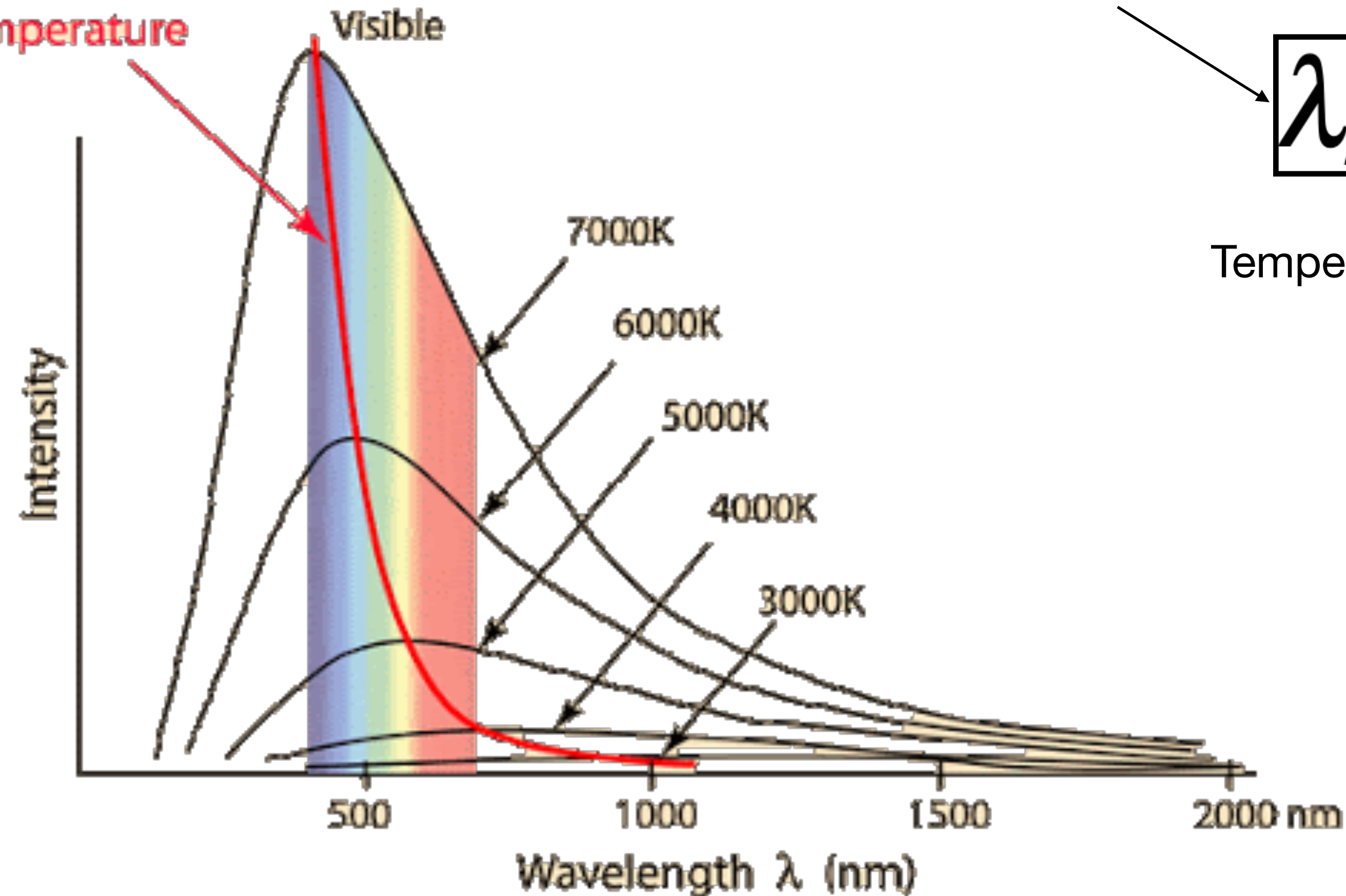
Max Karl Ernst Ludwig Planck [FRS^{\[1\]}](#) (German: [\[maks 'plan̩k\]](#) [listen](#));^[2] English: [/ˈplæn̩k/](#); ^[3] 23 April 1858 – 4 October 1947) was a [German theoretical physicist](#) whose discovery of [energy quanta](#) won him the [Nobel Prize in Physics](#) in 1918.^[4]



“Father of quantum mechanics”

Wien's displacement law: When the temperature of a blackbody radiator increases, the peak of the radiation curve moves to shorter wavelengths.

Decrease of λ_{peak} with increase in temperature



Peak wavelength of the radiation curve

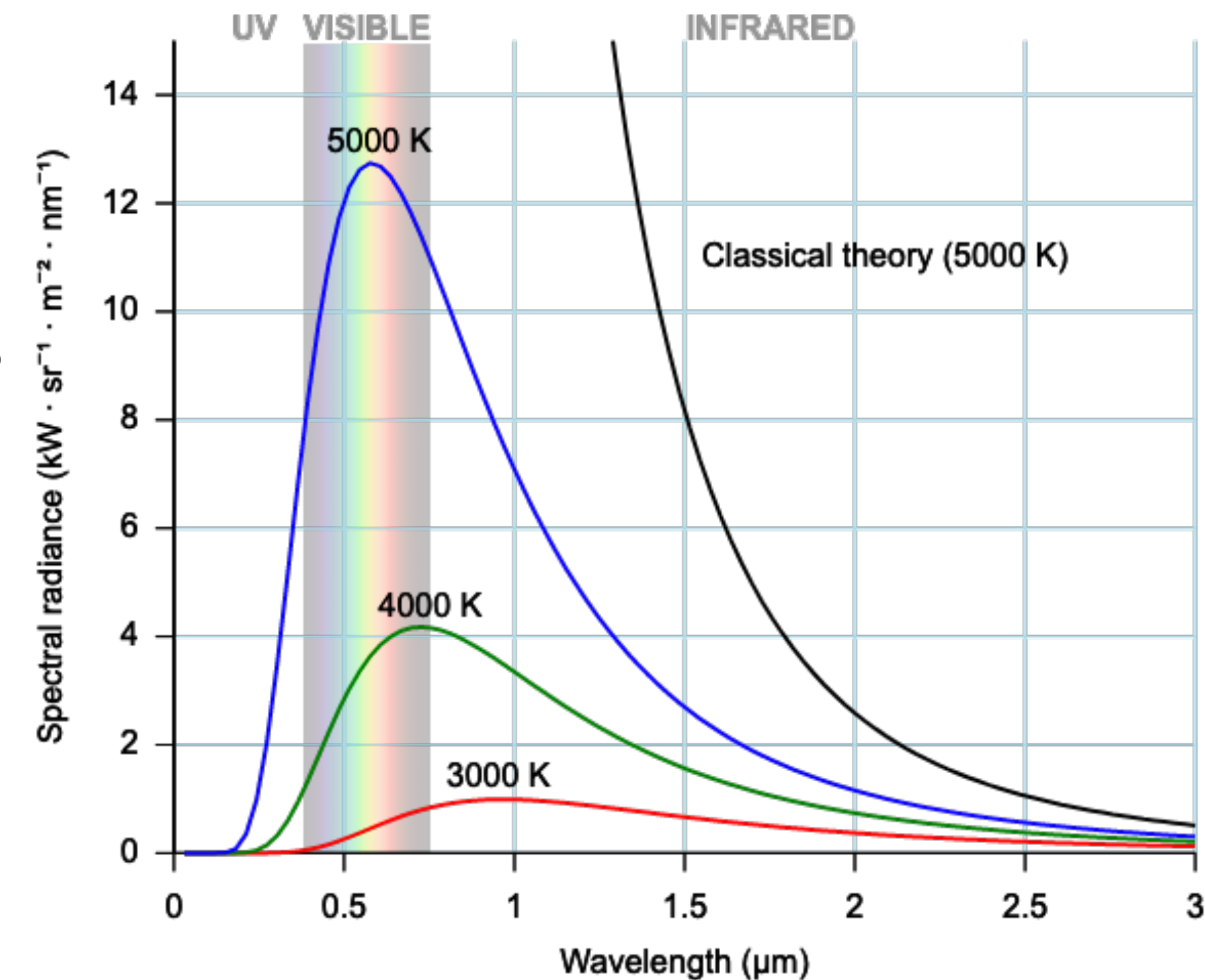
$$\lambda_m T = 2897 \mu\text{m} \cdot \text{K}$$

Temperature of the blackbody

As T increases:
- Intensity increases
- Peak wavelength decreases

Stefan-Boltzman law:

The radiative flux emitted by an object is the integral over wavelength of the Planck curves shown here:



$$F = \sigma T^4$$

$\sigma = 5.67 \cdot 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
(Stefan–Boltzmann constant)

Objects at a higher T emit more radiation (F)

⚡ Units! Temperature is in Kelvin, F is in W/m² (K = °C + 273.15)

Kirchhoff's law:

for real object

At a given wavelength, a real object emits / absorbs a fraction $\epsilon_\lambda / a_\lambda$ of the radiation a blackbody would emit/ absorb at a given temperature.

ϵ_λ = emissivity

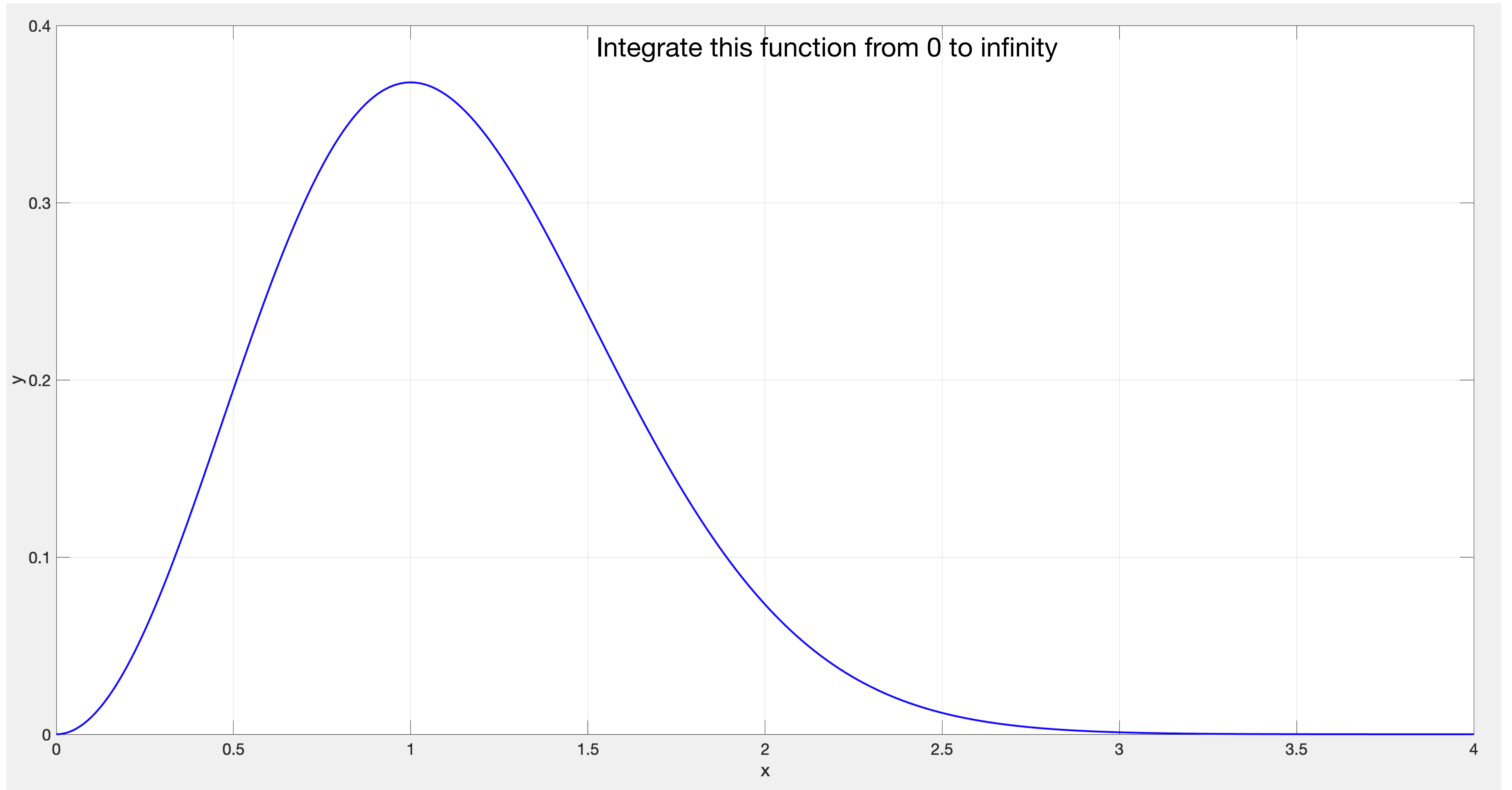
a_λ = absorptivity

$$a_\lambda = \epsilon_\lambda$$

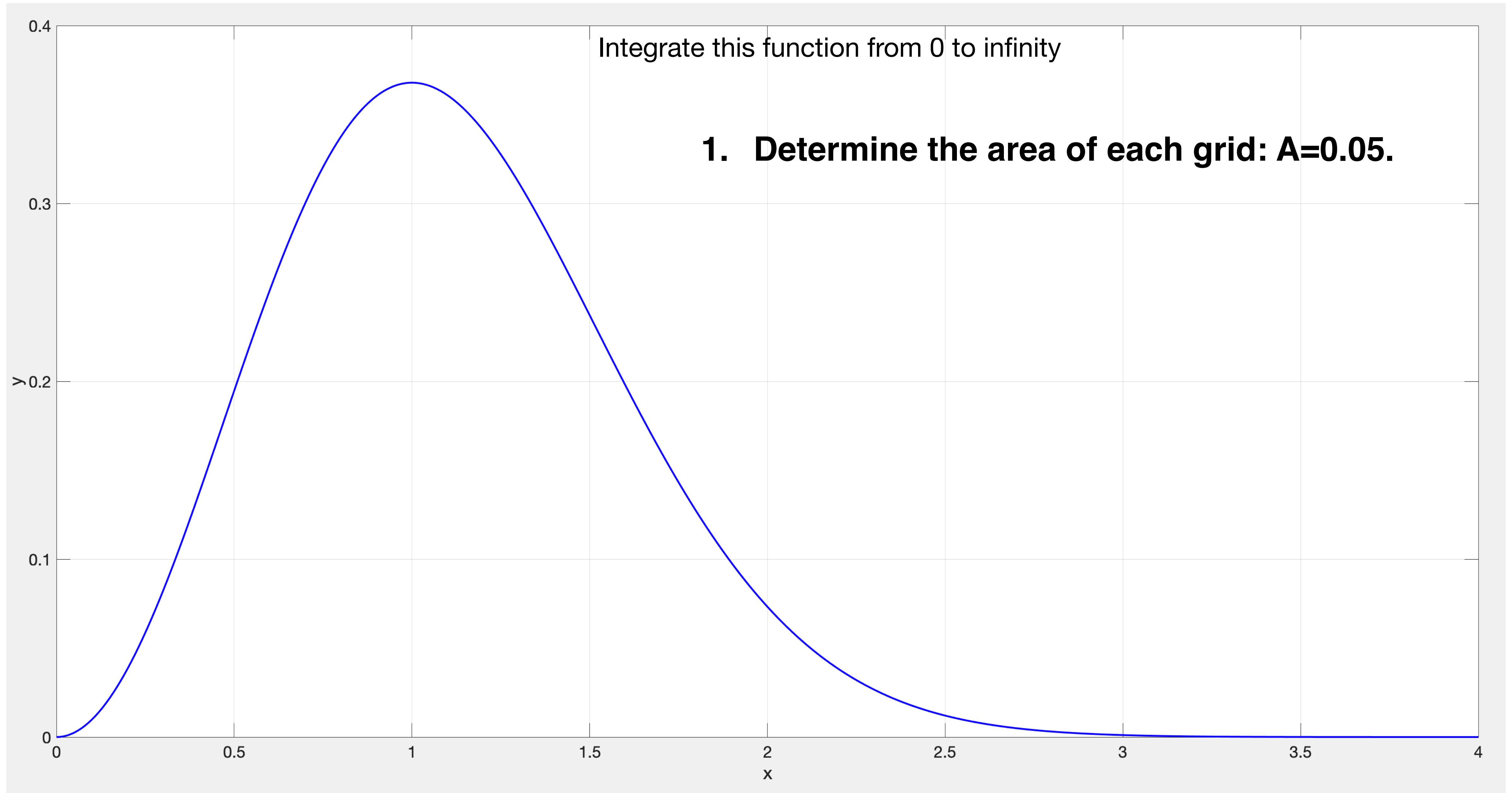
Both are between 0 and 1

Black Body?

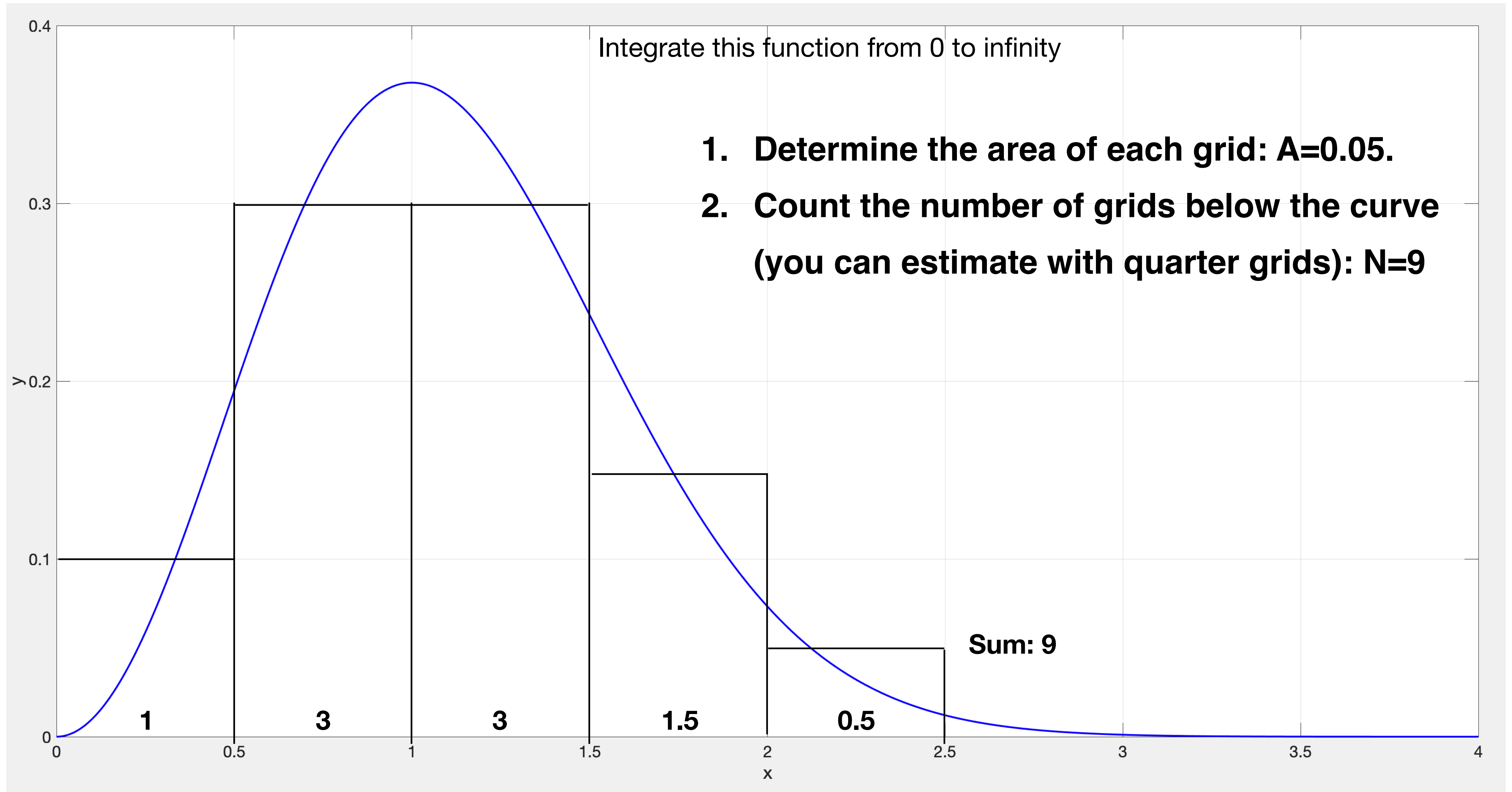
How to calculate integrals: The integral of the function is the area below it!



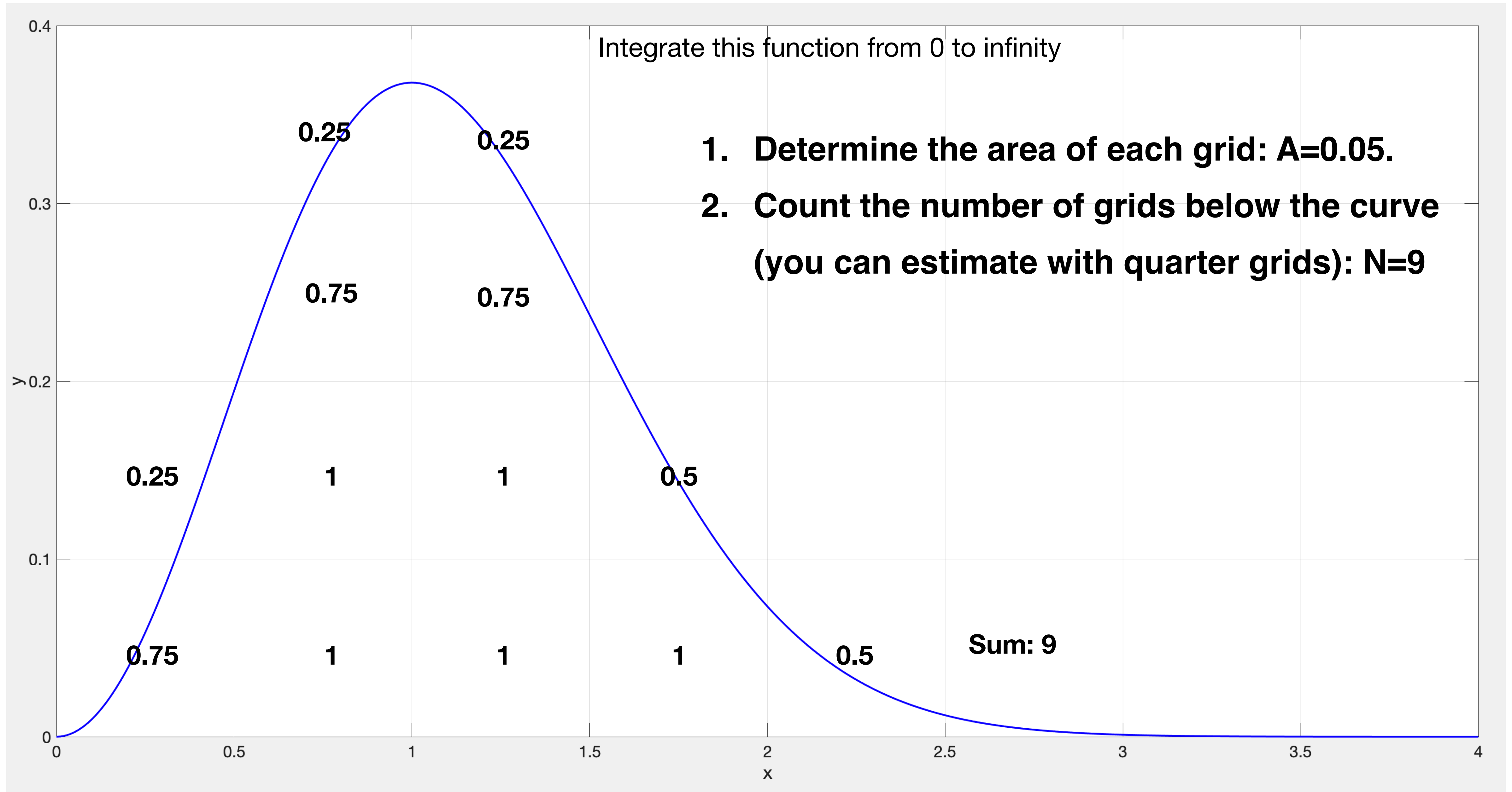
How to calculate integrals: The integral of the function is the area below it!



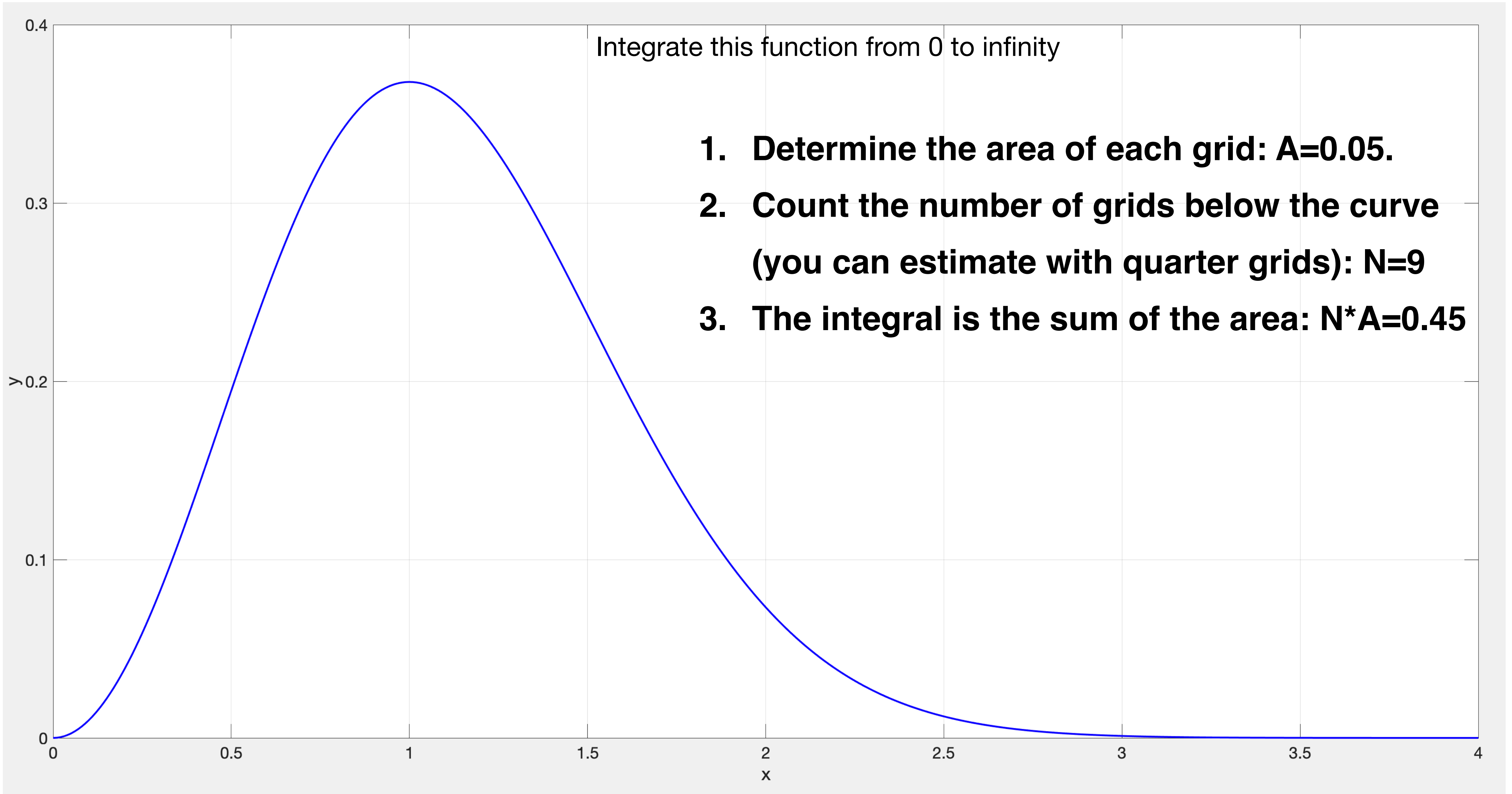
How to calculate integrals: The integral of the function is the area below it!



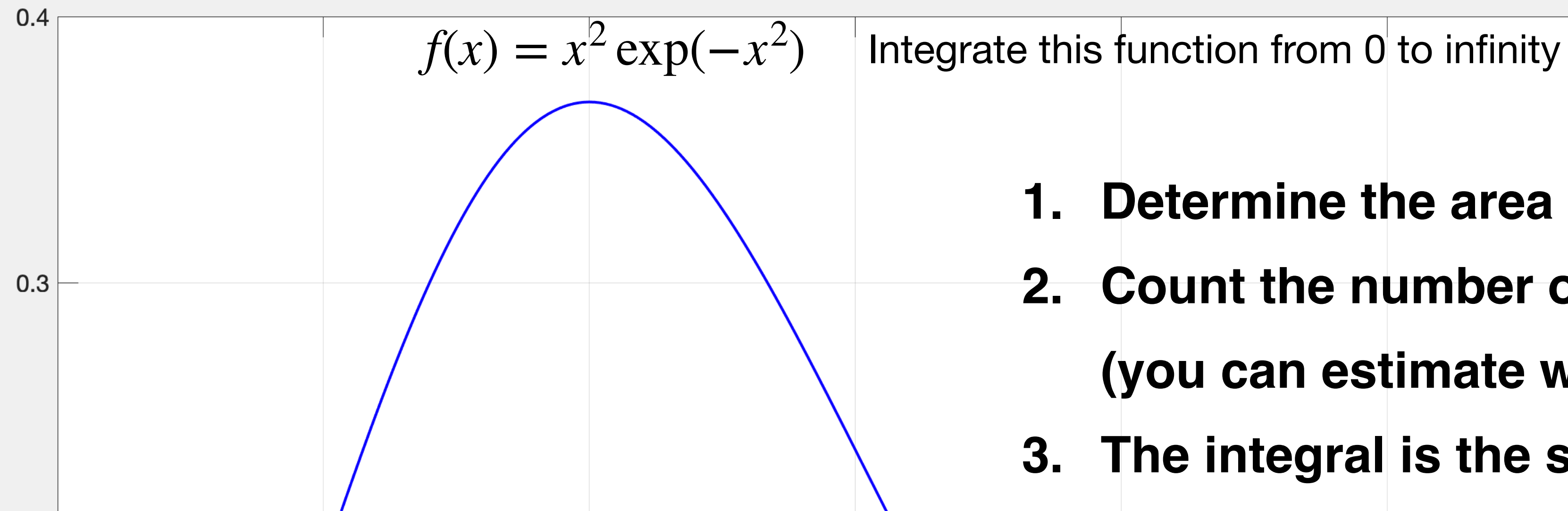
How to calculate integrals: The integral of the function is the area below it!



How to calculate integrals: The integral of the function is the area below it!



How to calculate integrals: The integral of the function is the area below it!



1. Determine the area of each grid: $A=0.05$.
2. Count the number of grids below the curve (you can estimate with quarter grids): $N=9$
3. The integral is the sum of the area: $N \cdot A=0.45$



integral ($x^2 \exp(-x^2)$) from 0 to infinity

NATURAL LANGUAGE MATH INPUT

EXTENDED KEYBOARD EXAMPLES UPLOAD RANDOM

Definite integral

[More digits](#)

$$\int_0^{\infty} x^2 \exp(-x^2) dx = \frac{\sqrt{\pi}}{4} \approx 0.443113$$

Indefinite integral

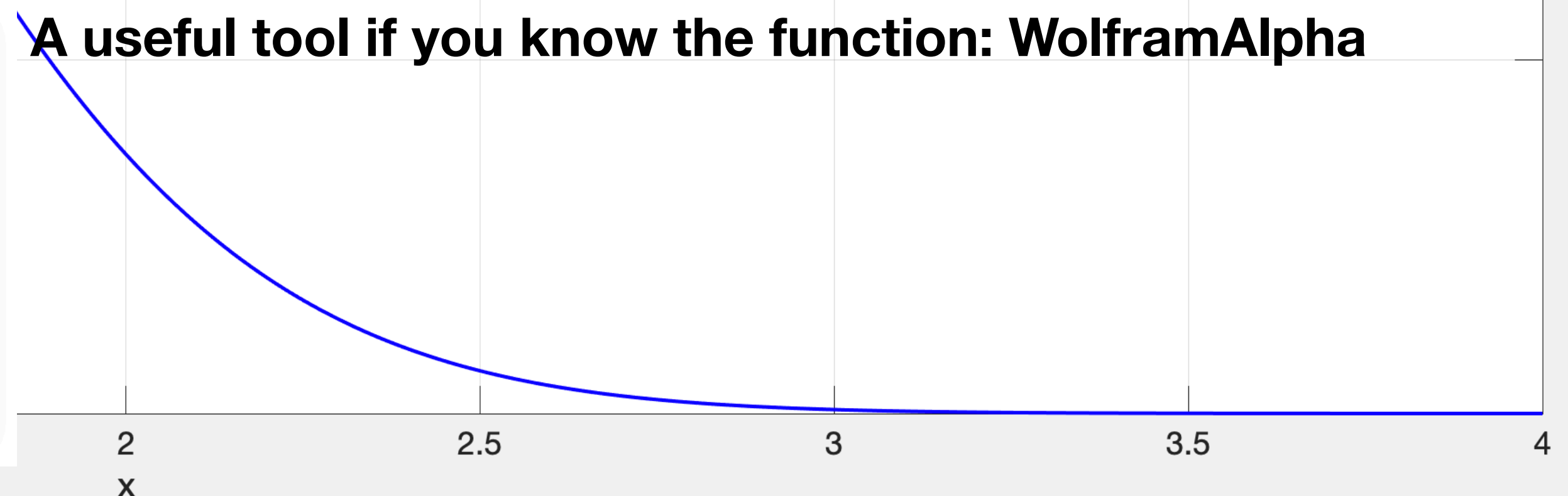
$$\int x^2 \exp(-x^2) dx = \frac{1}{4} \sqrt{\pi} \operatorname{erf}(x) - \frac{1}{2} e^{-x^2} x + \text{constant}$$

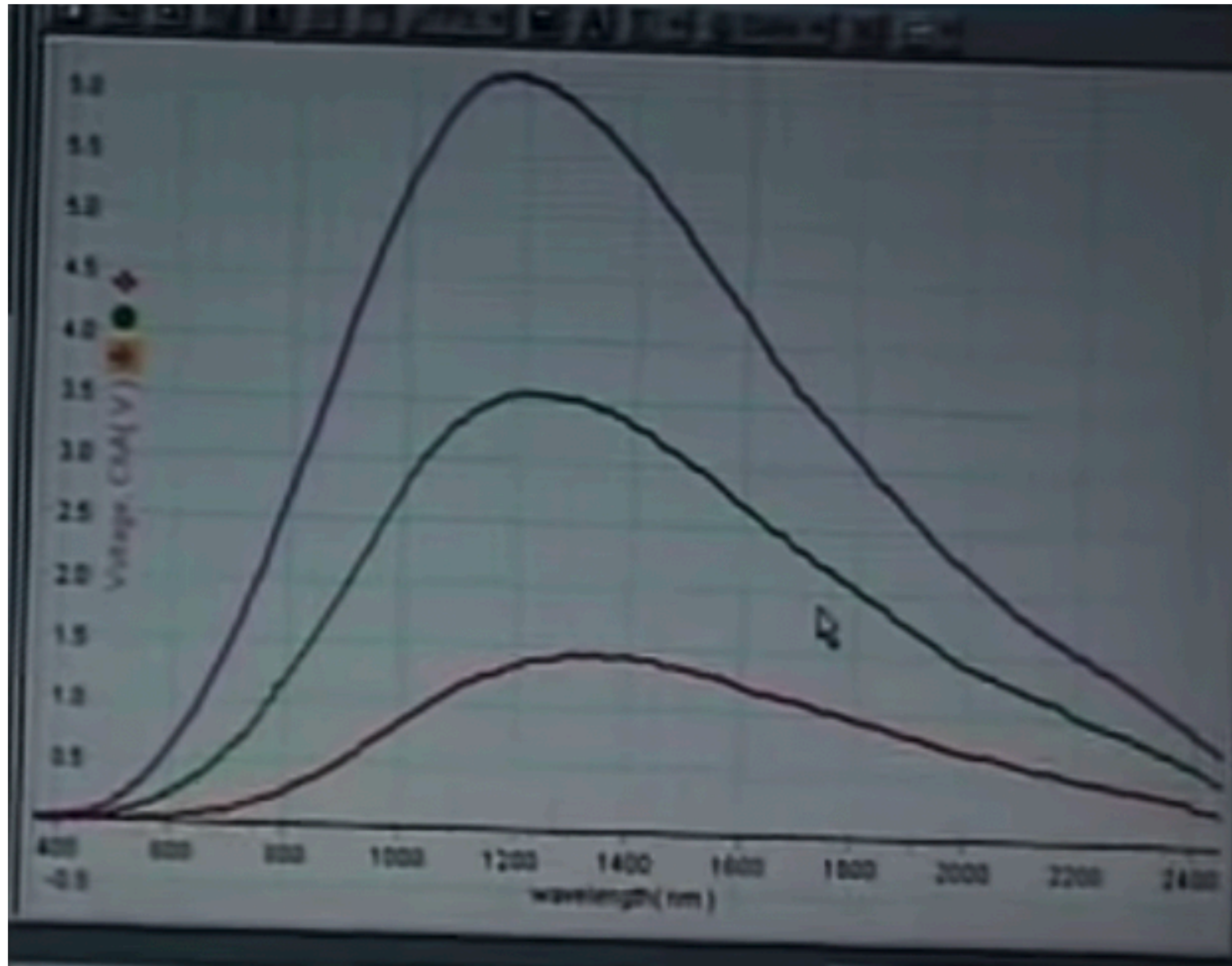
$\operatorname{erf}(x)$ is the error function

Download Page

POWERED BY THE WOLFRAM LANGUAGE

A useful tool if you know the function: WolframAlpha





wavelength (nm)

$$1 \text{ nm} = 10^{-3} \mu\text{m}$$

Wien's displacement law

$$\lambda_m T = 2897 \mu\text{m} \cdot K$$

Stefan-Boltzmann law

$$F = \sigma T^4$$

Kirchhoff's law

$$\epsilon_\lambda = a_\lambda$$