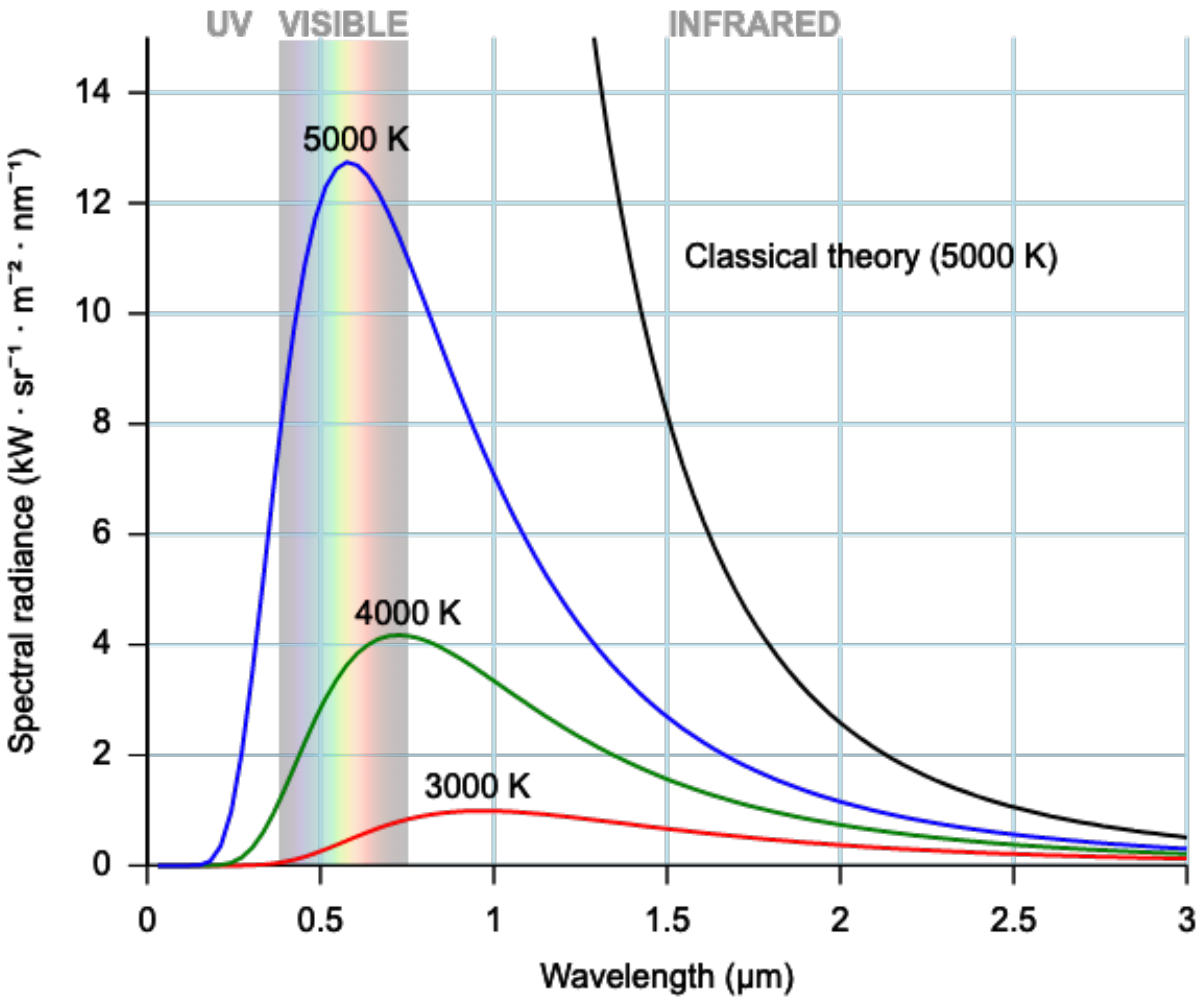
Global Warming
Lecture 3.4
Blackbody Radiation

Blackbody:

Blackbodies are perfect emitters and absorbers of electromagnetic radiation

They emit radiation at different wavelengths according to the Planck Function



Planck function

⬇

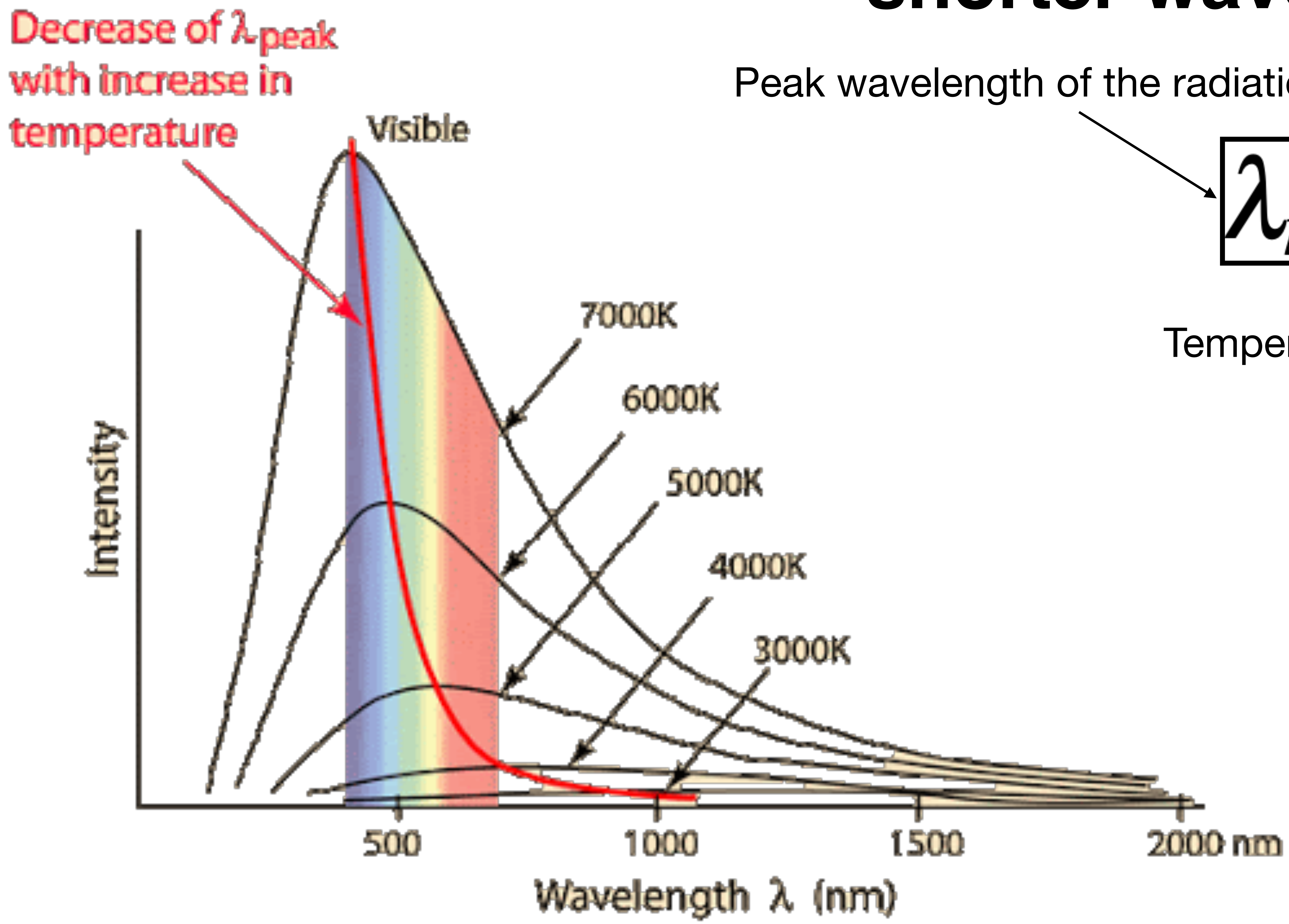
hotter bodies emit more radiation and have a peak emission at a shorter wavelength

Who is Planck?

Max Karl Ernst Ludwig Planck FRS[1] (German: [maks ˈplaŋk] (listen);[2] English: /ˈplæŋk/;[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.



Peak wavelength of the radiation curve

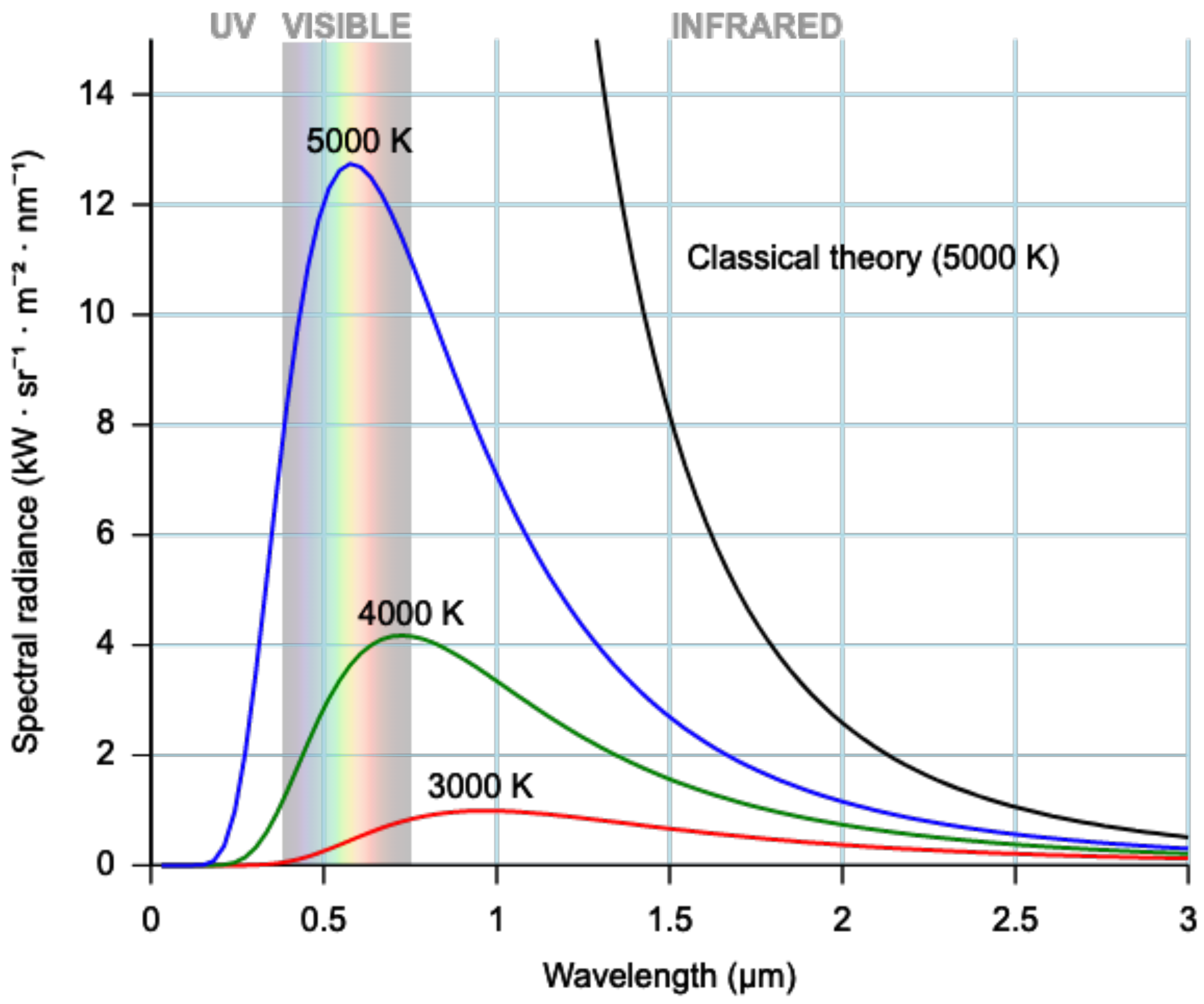
$$\boxed{\lambda_m}\boxed{T} = 2897\ \mu\mathrm{m} \cdot \mathrm{K}$$

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:



$$F = \sigma T^4$$

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

Objects at a higher T emit more radiation (F)

Units! Temperature is in Kelvin, F is in W/m^2 (K = ^{o}C + 273.15)

Kirchhoff's law:

for real object

At a given wavelength, a real object emits / absorbs a fraction ε_λ / a_λ of the radiation a blackbody would emit/ absorb at a given temperature.

ε_λ = emissivity

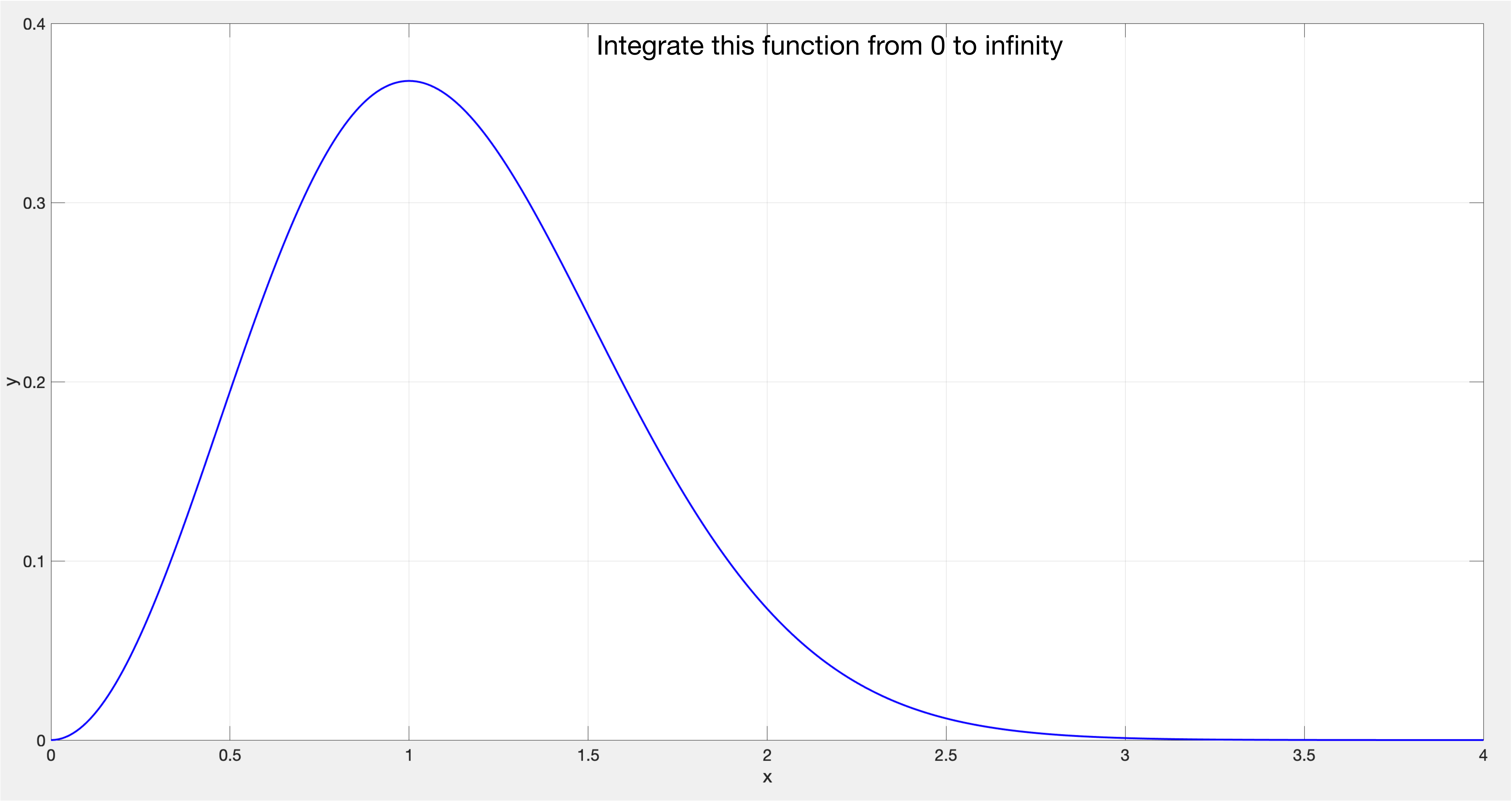
a_λ = absorptivity

$$a_\lambda = \varepsilon_\lambda$$

Both are between 0 and 1

Black Body?

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



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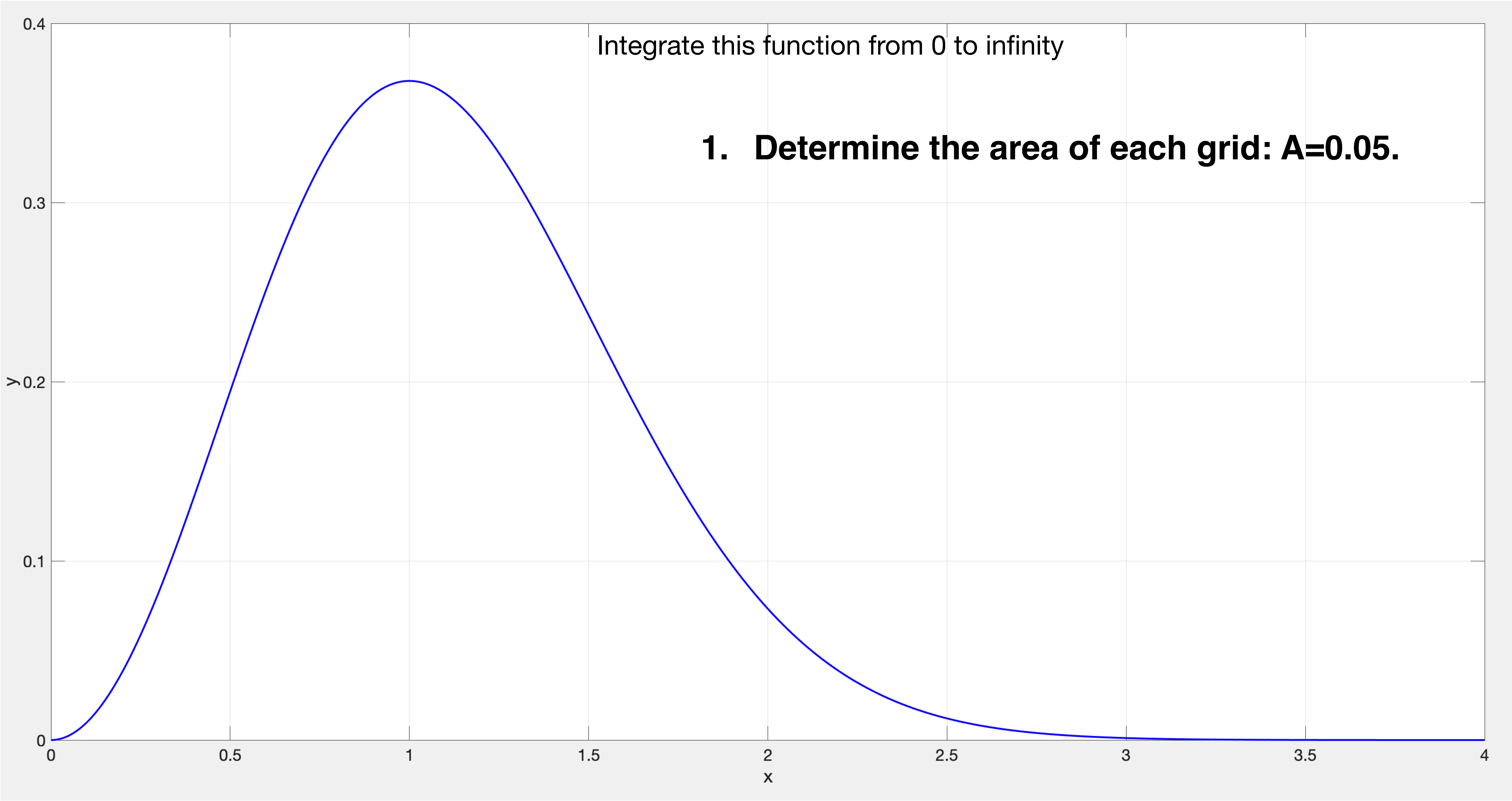

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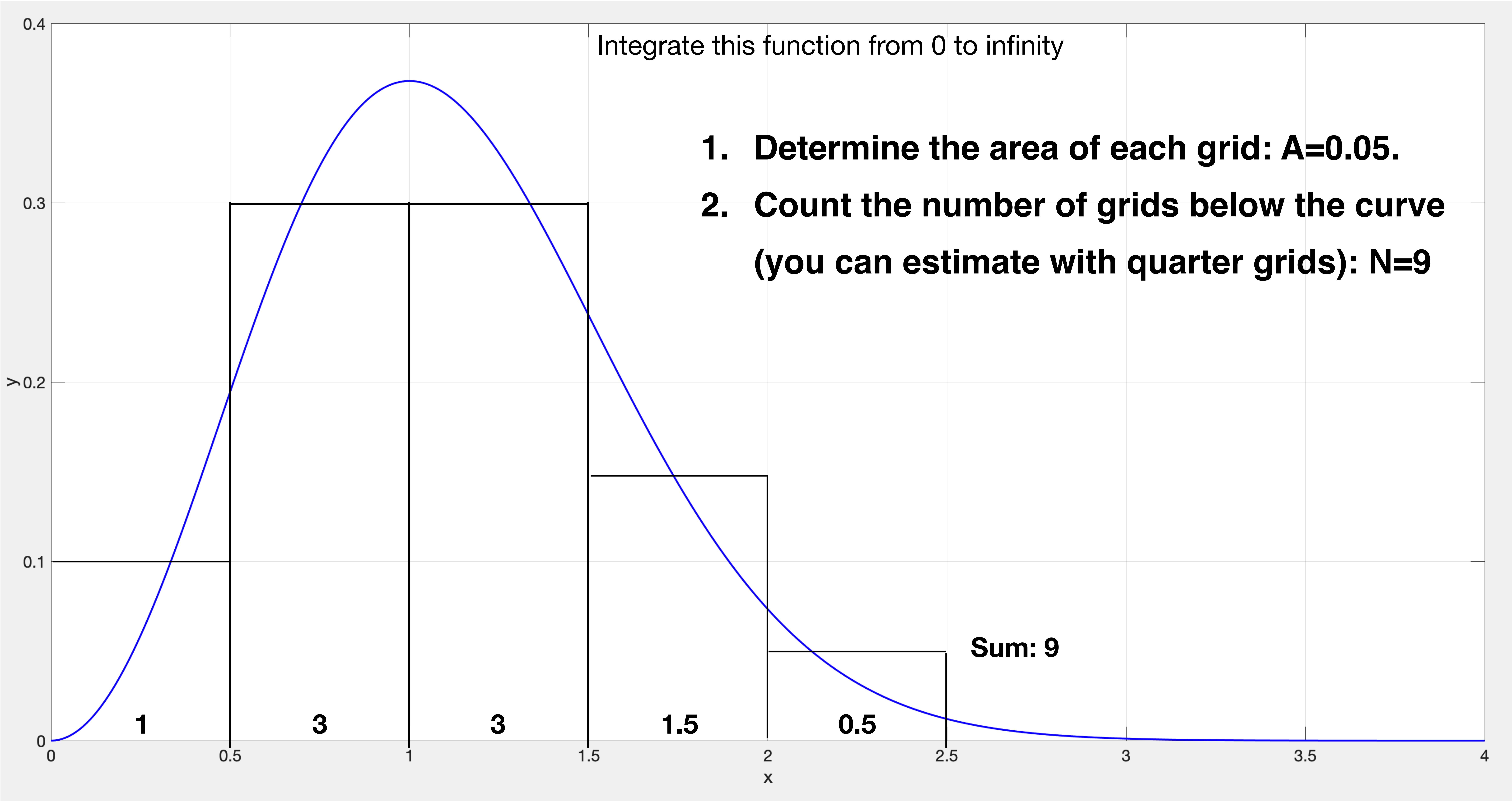

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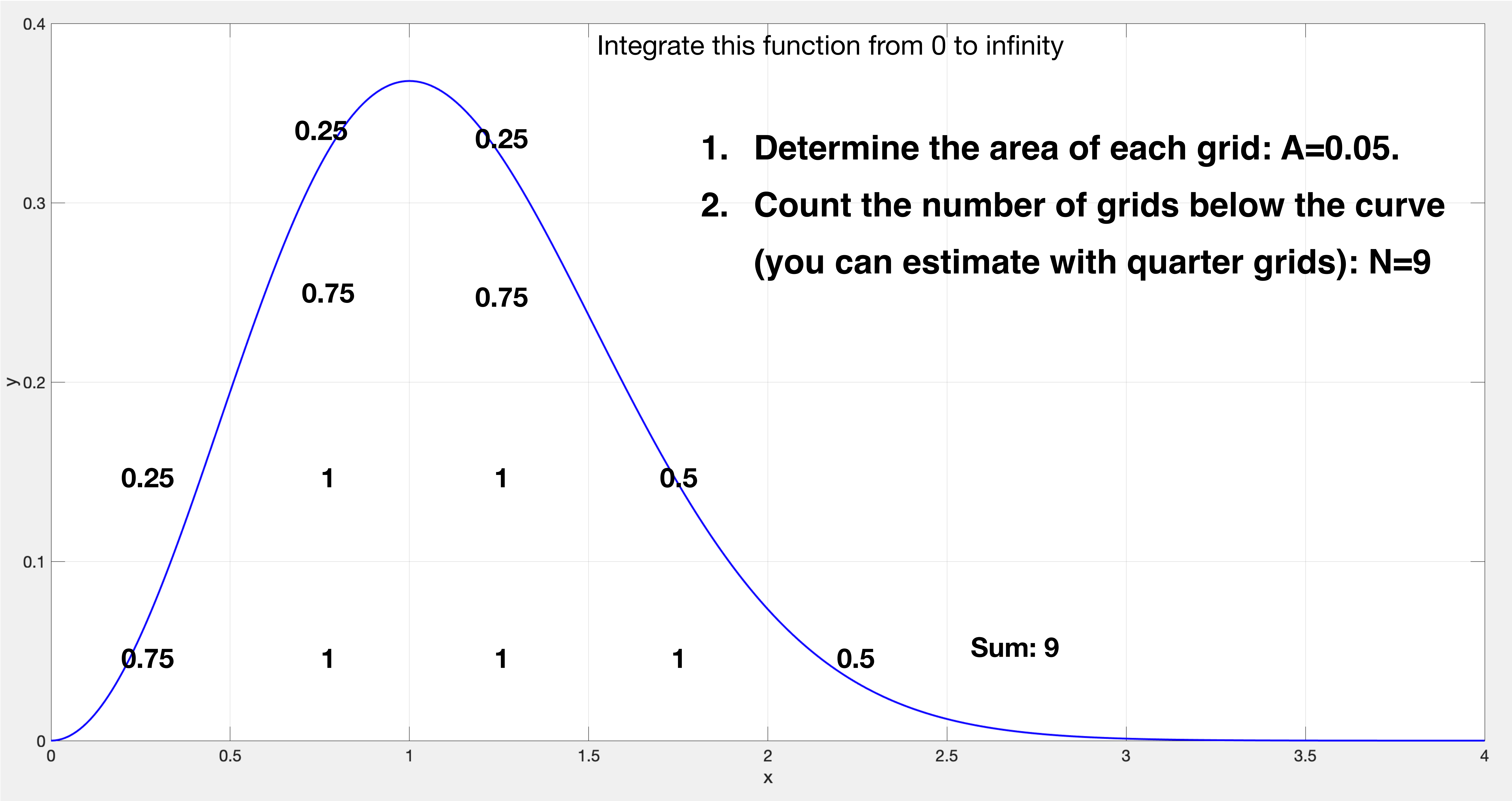

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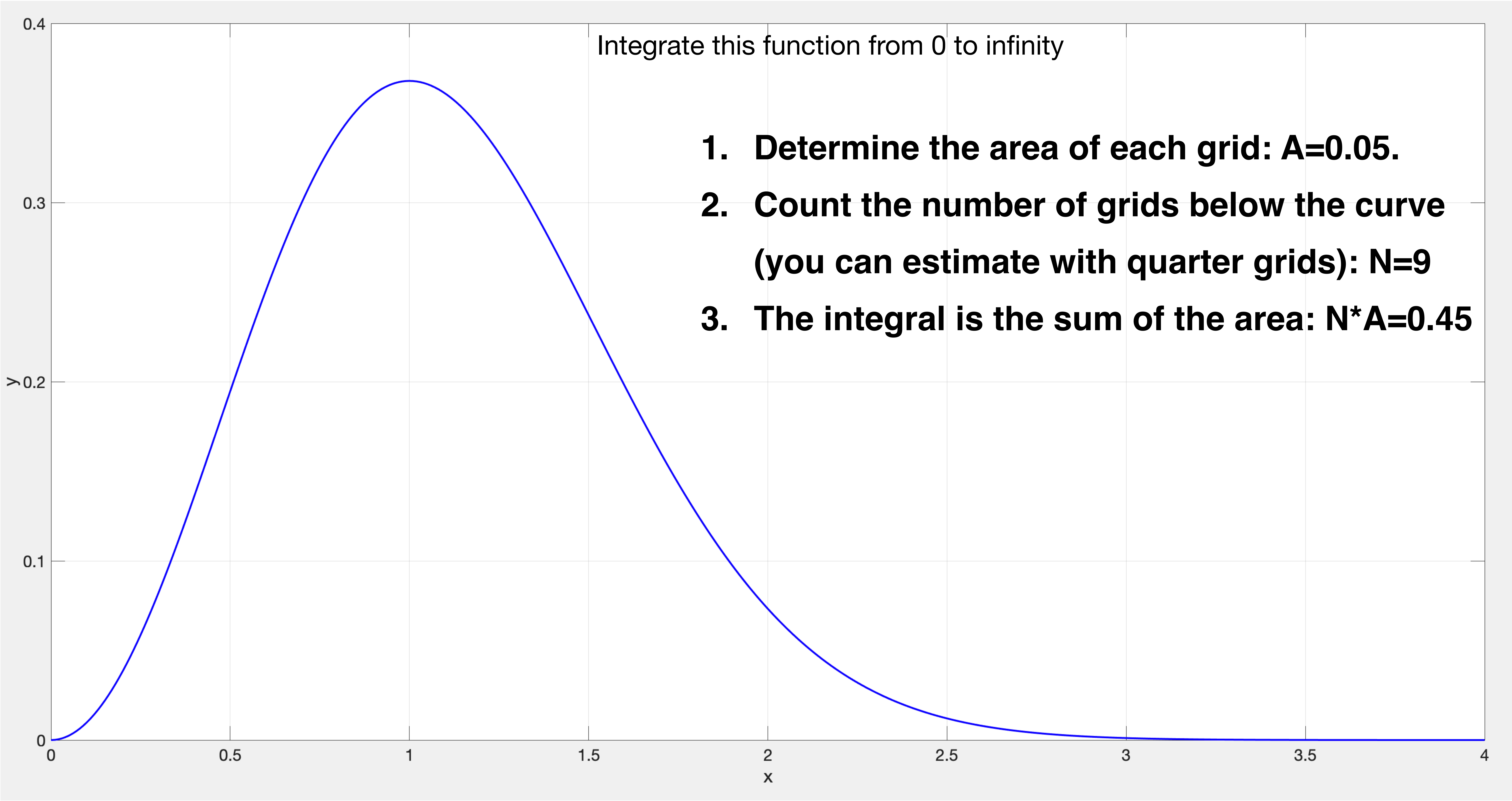

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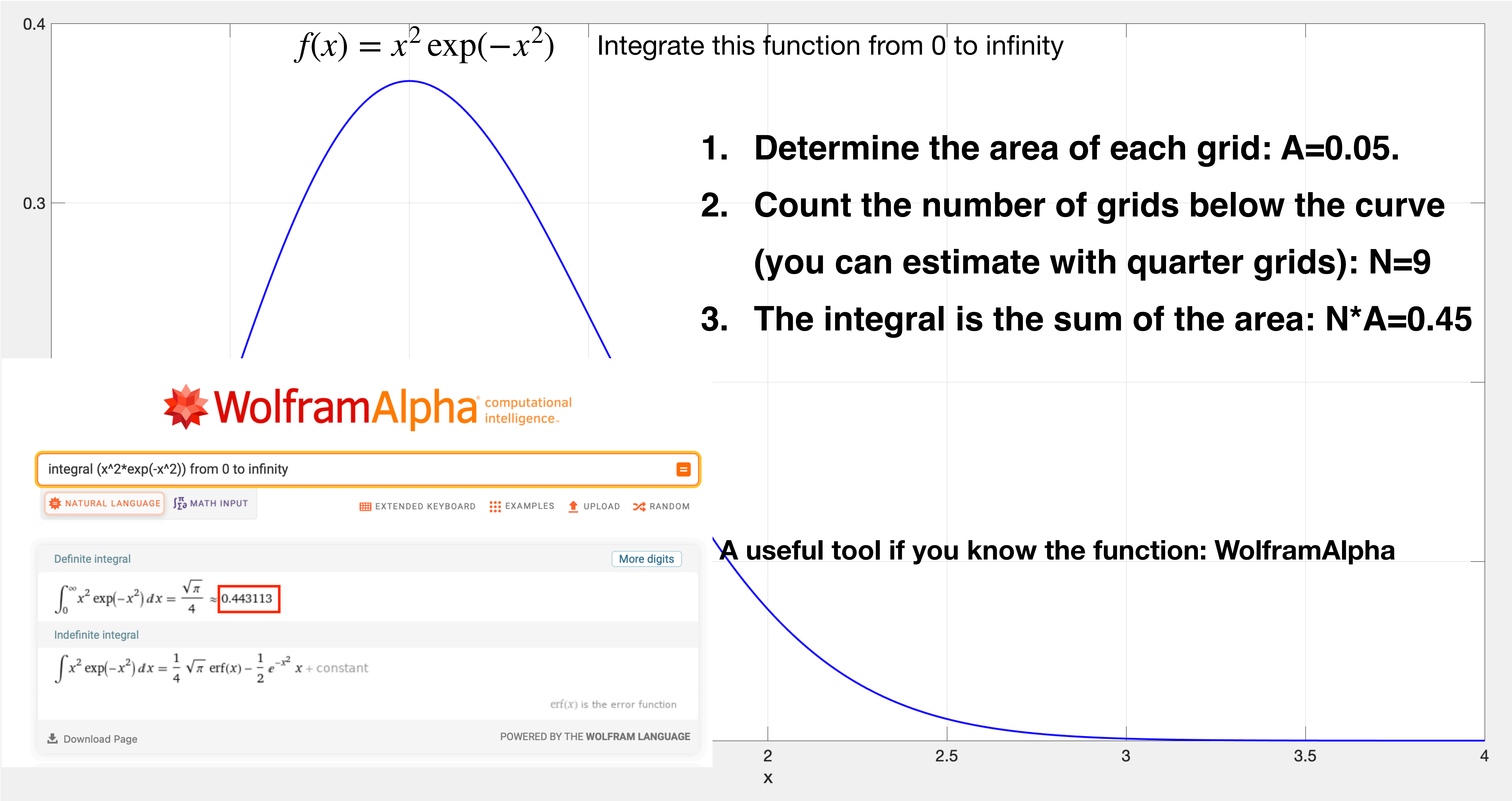
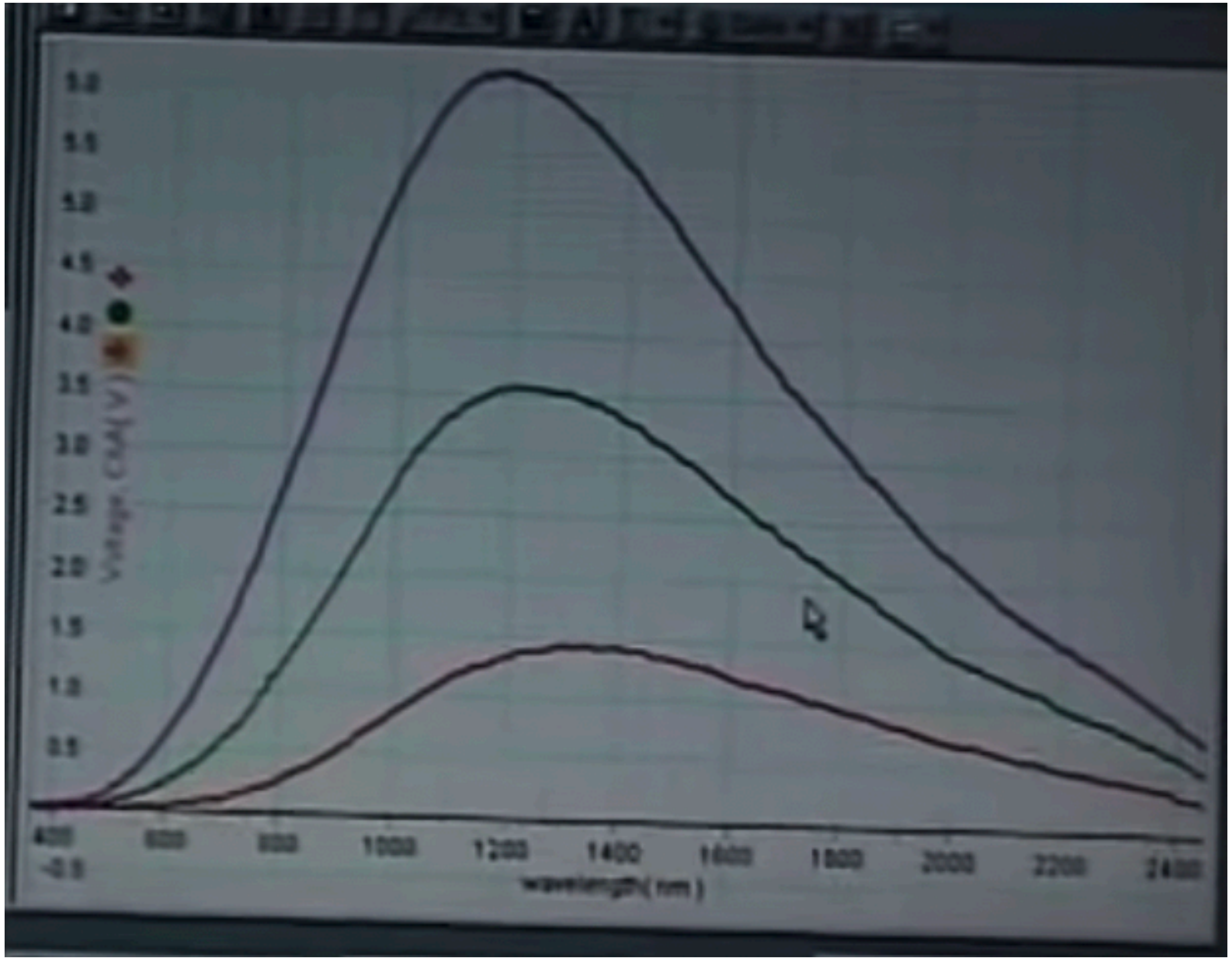


$$f(x) = x^2 \exp(-x^2)$$

Integrate this function from 0 to infinity

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*A=0.45**

A useful tool if you know the function: WolframAlpha



wavelength (nm)

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

Wien's displacement law

$$\lambda_m T = 2897\ \mu m \cdot K$$

Stefan-Boltzmann law

$$F = \sigma T^4$$

Kirchhoff's law

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