Fisi 4125 *23 de febrero de 2021*

Universidad de Puerto Rico
Recinto Universitario de Mayagüez
Departamento de Física
Asignación 4

Instrucciones: Para entregar en o antes del martes, 2 de marzo de 2021 a las 11:59 PM (20 puntos = 100%).

1.

Heat capacity of a solid: Debye's theory of solids gives the heat capacity of a solid at temperature T to be

$$C_V = 9V\rho k_B \left(\frac{T}{\theta_D}\right)^3 \int_0^{\theta_D/T} \frac{x^4 e^x}{(e^x - 1)^2}\, dx,$$

where V is the volume of the solid, ρ is the number density of atoms, k_B is Boltzmann's constant, and θ_D is the so-called *Debye temperature*, a property of solids that depends on their density and speed of sound.

(a) Write a Python function `cv(T)` that calculates C_V for a given value of the temperature, for a sample consisting of 1000 cubic centimeters of solid aluminum, which has a number density of $\rho = 6.022 \times 10^{28}\,\mathrm{m}^{-3}$ and a Debye temperature of $\theta_D = 428\,\mathrm{K}$. Use the trapezoidal rule to evaluate the integral with $N = 1000$ sample points. Hint: The value of the integrand at $x = 0$ is zero.

(b) Use your function to make a graph of the heat capacity as a function of temperature from $T = 5\,\mathrm{K}$ to $T = 500\,\mathrm{K}$.

2.

Simpson's rule:

(a) Write a program to calculate an value for the integral $\int_0^2 (x^4 - 2x + 1)\, dx$ from Example 5.1, but using Simpson's rule with ten slices instead of the trapezoidal rule.

(b) Run the program and compare your result to the known correct value of 4.4. What is the fractional error on your calculation?

(c) Modify the program to use a hundred slices instead, then a thousand. Note the improvement in the result. How do the results compare with those from Example 5.1 for the trapezoidal rule with the same number of slices?

Instrucciones para Entregar sus Asignaciones

1) Prepare un archivo en pdf con la información que pide el ejercicio. Por ejemplo, si el ejercicio pide que escriba un programa, deberá mostrar su programa. Si el ejercicio pide output para un input dado, deberá mostrar el input y el output. Este archivo lo subirá a la plataforma Moodle del curso.

2) Suba también en archivos separados los programas usados para la hacer la asignación a la plataforma Moodle.