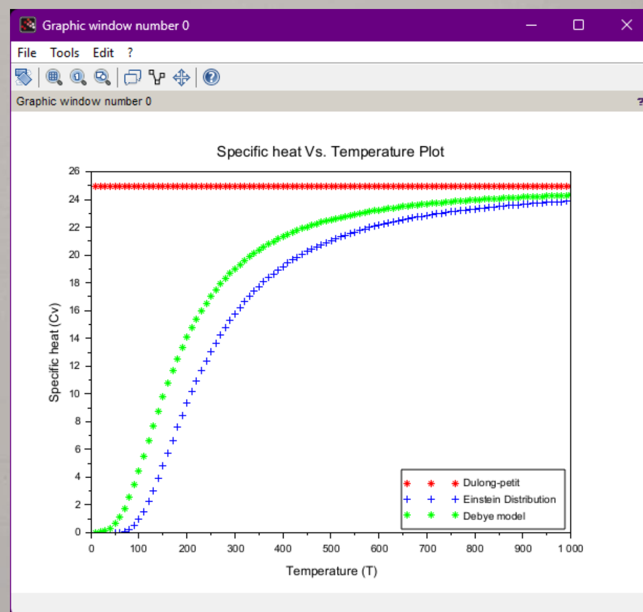
Aim: Plot specific heat of solids (a) Dulong - petit law (b) Einstein distribution law (c) Debye distribution for high & low temperature and compare them

Apparatus: Scilab with latest version

```
R=8.314;
h=6.625*10.^-34;
k=1.38*10.^-23;
v=15*10^12;
for T=10:10:1000;
    DP=3*R; //Dulong petit law
    a=(h*v)/(k*T);
    E=(((3*R)*(a^2)*(exp(a)))/((exp(a)-1)^2)); // Einstein distribution law
    funcprot(0)
    function c=f(x)
        c=(x^4)*exp(x)/((exp(x)-1)^2);
    endfunction
    D=(9*R*((1/a)^3)*intg(0,a,f)); //Debye Distribution law
    plot(T,DP,'r*');
    plot(T,E,'b+');
    plot(T,D,'g*');
end
xlabel('Temperature (T)')
ylabel('Specific heat (Cv)')
title('Specific heat Vs. Temperature Plot')
legend('Dulong-petit','Einstein Distribution','Debye model',4)
// Comparison Results
printf("Comparison Results:\n");
printf("At high temperature, all models converge to Dulong-Petit value (3R).\n");
printf("At low temperature, Debye model follows T^3 dependence, while Einstein model deviates from experimental results.\n");
```



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Aim: To plot Specific heat of solids (a) Dulong - petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature & low temperature and compare them for these two cases. using scilab

Apparatus: Scilab with latest version

Theory: Specific heat of solids is a fundamental property that describes how much heat energy is required to change the temperature of a solid material

Dulong - petit law: This law states that the molar specific heat capacity of a solid element is approximately constant at high temperature and is given by:

$$C_V = 3R \quad R\text{- Gas constant}$$

This law is derived from the classical approaches of equipartition theorem, assuming that each atom in a solid contributes equilly to the total thermal energy It holds well at high temperature but fails at low temperature, where quantum effect dominate.

Einstein model of specific heat:- He assumed that all atoms in a solid oscillate Independendly with the same frequency ν

$$C_V = 3R\left(\frac{x^2 e^x}{(e^x-1)^2}\right), \quad x = \frac{h\nu}{k_B T}$$

At high temperatures ($T >> \theta_E$), the model approaches the Dulong petit limit, $C_V \approx 3R$

At low ($T << \theta_E$) $C_V \propto e^{-h\nu/k_B T}$

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Debye model of Specific heat: Debye extended Einstein's model by considering a continuous range of vibrational frequencies (phonons) instead of a single frequency.

$$C_v = 9R\left(\frac{T}{\theta_D}\right)^3 \int_0^{\theta_D/T} \frac{x^2 e^x}{(e^x-1)^2}\,dx \qquad x = \frac{h\nu}{K_B T}$$

At high temperatures $T >> \theta_D$, The Debye model also converges to the dulong petit law

At low temperatures, ~~the Einstein model~~ C_v follows the Debye T^3 law

$$C_v \propto T^3$$

Code:

```
R= 8.314;
h = 6.625* 10.^-34;
k = 1.38 * 10.^-23;
v = 15* 10^12;
for T = 10:10:1000;
    DP = 3R;
    a = (h*v)/(K*T);
    E = (((3*R)*(a^2)*exp(a)))/(exp(x)-1)^2));
    funcprot(0)
    function c = f(x)
        c = (x^4)*exp(x)/((exp(x)-1)^2);
    endfunction
    integral= intg(0,a,f);
    D=(9*R*((1/a)^3)*integral);
```

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```
        plot(T, DP, 'r*');
        plot(T, E, 'b+');
        plot(T, D, 'g+');
end
xlabel('Temperature(T)');
ylabel('specific heat (Cv)');
title('specific heat vs Temperature plot');
legend('Dulong petit','Einstein Distribution','Debye model',4);
```

Result:

At high temperature, all models converge to Dulong petit value (3R)

At low temperature, Debye model follows T^3 dependence, while einstein model deviates from experimental results