The Gaussian probability distribution becomes the Maxwell distribution formula, which is convenient to write in a form which separates the variables from the constants.

$$f(\text{v})dv = 4\pi\left(\frac{m}{2\pi k_B T}\right)^{\frac{3}{2}} e^{-\frac{m\text{v}^2}{2k_BT}}\text{v}^2 d\text{v} = \underbrace{4\pi\left(\frac{m}{2\pi k_B}\right)^{\frac{3}{2}}}_{A_1} \text{T}^{-3/2} e^{-\frac{b}{T}\text{v}^2}\text{v}^2 d\text{v} \quad (1.1)$$

$$\text{with b} = \frac{m}{2k_B} = \frac{M_{mol}}{2R}; A_1 = \frac{4}{\sqrt{\pi}} b^{\frac{3}{2}}$$

Note that the constant A_1 is not the constant A in the lecture.

For N particles per m^3, we just multiply the formula by N and obtain the number of particles N_v with velocities between v and v + dv.
For the most probable speed we take the derivative of f(v) with respect to v and, setting it equal to 0, we find (see lecture):

$$\text{v}_{mp} = \sqrt{\frac{2kT}{m}} = 1.4\sqrt{\frac{kT}{m}} = 1.4\sqrt{\frac{RT}{M}} \quad (1.2)$$

$$\bar{\text{v}} = \int_0^\infty \text{v} f(\text{v}) d\text{v} = \sqrt{\frac{8k_BT}{\pi m}} = 1.6\sqrt{\frac{k_BT}{m}} \quad (1.3)$$

$$\text{v}_{rms} = \int_0^\infty \text{v}^2 f(\text{v}) d\text{v} = \sqrt{\frac{3k_BT}{m}} = 1.73\sqrt{\frac{k_BT}{m}} \quad (1.4)$$

Lab assignment:
Assume that you have **3.00E20 helium atoms per 3 liters.**
Choose 50 m/s for your intervals on the variable axis, from 0 to 10,000m/s.

1. Calculate: b=______________________
2. A_1=______________________

For the following temperatures calculate and **draw in Excel the Maxwell distribution curves** on one graph: T=1700K, Ta=1000K, Tb=2500K.

Calculate for T=1700K:

3. the **average velocity at 1700K =(   )**
4. **the most probable velocity at 1700K**
5. **and the rms velocity at at 1700K (   )** and indicate these values on your Excel graph, use a pen.
6. Use the trapezoidal rule in Excel to calculate the percentage of the atoms having a speed higher than twice the rms speed for T=1700K.

7. Calculate the **mean free time** ( )
8. and **path ( ),** using the rms velocity.
9. Also, calculate the **pressure ( )**. Take the diameter of an Helium atom to be 2.00E-9m. It's molar mass is 4.00 grams.

$$\text{mean free path } \lambda = \frac{\text{average distance}}{\text{number of collisions}} = \frac{1}{\sqrt{2}\pi d^2 n_V}; \tau = \frac{\lambda}{\overline{\text{v}}}$$

$$d = 2r = \textit{diameter} \text{ of target cylinder; } \text{n}_\text{V} = \frac{N}{V} = \text{number-density}$$

$$\text{number of collisions} = \sqrt{2}\pi d^2 n_V \overline{\text{v}} \Delta t$$

Your lab report must include the four graphs of the four Maxwell distributions together (from 0 to 10,000K) and the one at 1700K separately (from 0 to 8000K). On the 1700 K graph, indicate with a pencil the approximate locations of the three different velocities : most probable, average, and rms.
Also, shade the area under the graph corresponding to values larger than twice the rms speed.
Also, show the first 10 lines of your data for the calculations of the Maxwell curves.