**Guiding Questions**
- What powers stars?
- How do we know?
- How long can they last?

**Do:**
- NSE #10.1, chem #10.3; give Ex 10.3.9 from Ex 10.4

**Background:**
- C.8 - Maxwell Boltzmann distribution

Number of particles with speed between \( v \) and \( v + dv \) is

\[
v dv = n \left( \frac{m}{2\pi kT} \right)^{3/2} \frac{4\pi v^2 e^{-\frac{mv^2}{2kT}}}{(2\pi kT)^{3/2}} dv \quad (8.1)
\]

Plot \( \frac{v^2}{2} \) vs. \( e^{-av^2} \)

Combine \( n_v dv \sim v^2 e^{-av^2} \)

Find \( v_{mp} \) at the peak: \( \frac{dv}{dv} = 0 \)
\[ \text{V}_{\text{mp}} = \sqrt{\frac{3kT}{m}} = \text{most probable speed (at PEAK) (SHOW)} \]

Where is \( \text{V}_{\text{rms}} = \sqrt{\frac{3kT}{m}} \) on the plot?

**TAIL:** Some atoms are much faster ("hotter") than \( \text{V}_{\text{mp}} \) or \( \text{V}_{\text{rms}} \). The fast tail lets the gas do things you wouldn't expect at \( T \).

Recall from thermal physics:

\[ \text{thermal energy} = \text{kinetic energy} \]

\[ \frac{3}{2} kT = \frac{1}{2} m \text{V}_{\text{rms}}^2 \]

Constant \( k = 1.38 \times 10^{-16} \text{ erg K}^{-1} \text{mol}^{-1} \) or \( \text{K} \)

- **Ex:** Find \( \text{V}_{\text{rms}} \) for H gas with \( T = 10^4 \text{ K} \)

- **Derive** \( P = n kT \) from (8.1) : prob # 10.5
NEW in Calc: Hydrostatic Equilibrium (HSE)

\[ \Rightarrow \text{OUT: Pressure } P \text{ exerts force } F_p \]

\[ \Rightarrow \text{IN: Gravity } F_g = -\frac{GM_r}{r^2} \text{ in a distance from center} \]

\( M_r \) = enclosed by sphere of \( r \).

\[ \sum F = ma = 0 \text{ in equilibrium} \]

\[ F_g - F_p = 0 \]

\[ F_g = F_p \]

\[ \mu g = \frac{GM_M}{r^2} \]

How much mass is contained in the shell?

\( dM_r = \text{mass} \)

\[ dM_r = \text{density} \times \text{volume} \]

\[ \text{volume} = \text{Area} \times \text{thickness} \]

\[ dM_r = \text{Area} \times \text{thickness} \]

Mass contained inside radius \( r \) is \( M_r = \int dM_r = \int 2\pi r \text{dr} \)

\[ F_{\text{grav}} = \frac{mg}{\text{vol}} = \rho g, \text{ and } g = \frac{GM_r}{r^2} \]

So \( F_{\text{grav}} = \frac{mg}{\text{vol}} \)
Find force exerted by gas pressure

\[ F_p \]

\[ \text{Area} \]

\[ \frac{dP}{dr} \]

Pressure = \frac{\text{Force}}{\text{area}} \quad \text{and Volume} = \text{area} \cdot dr

So \[ \frac{\text{Force}}{\text{vol}} = \frac{\text{Force}}{\text{area} \cdot dr} = \frac{dP}{dr} = \frac{F_p}{\text{vol}} \]

Finally, combine \[ \frac{F_p}{\text{vol}} = \frac{F_p}{\text{vol}} \] to get HSE:

\[ \square \text{Do } \#10.1 - \text{express HSE in terms of } \pi \text{ Capacity} \]