Key points from Lecture 2 of ASTR 350

1. Newton: the same laws of physics operate everywhere in the universe (a major leap from previous thought!).
2. A lot of physics deals in *vectors*: things that have direction as well as magnitude. For example, velocity is a vector: to describe a car's motion you need its direction of motion as well as its speed. Often we use an arrow above a quantity, or boldface that quantity, to denote a vector: e.g., $\vec{v}$ or $\mathbf{v}$.
3. Newton's first law: unless acted on by a force, objects at rest stay at rest and objects in uniform-velocity motion stay that way (the law of inertia).
4. Newton's second law: force equals mass times acceleration ($\vec{F} = m\vec{a}$). Here the force $\vec{F}$ and the acceleration $\vec{a}$ are vectors, but the mass m is not; mass does not have a direction.
5. Newton's third law: for every action there is an equal but opposite reaction. Put another way, if some body A exerts a force $\vec{F}_{AB}$ on body B, then body B exerts a force $\vec{F}_{BA} = -\vec{F}_{AB}$ on body A.
6. We can express these laws in terms of *momentum* $\vec{p} = m\vec{v}$ for mass m and velocity $\vec{v}$. Newton's first and second laws say that a change in momentum requires a force, or if we put this in the language of calculus, $d\vec{p}/dt = \vec{F}$.
7. We can also put this in relation to *symmetries* and *conservation laws*. For symmetries, we know that (for example) empty space is the same anywhere and in any direction. The invariance of physical laws to location is a symmetry, as is the invariance of physical laws to when you measure them, as is the invariance of physical laws to the orientation of a system (in each case we consider an isolated system). A profound theorem by the great Emmy Noether tells us that for each such symmetry, we have a conserved quantity. Related to the previous symmetries, this means that for isolated systems, respectively, linear momentum, energy, and angular momentum do not change for that isolated system no matter how complicated the interactions are within that system.