Physics 109: Homework #6 Solutions

6.1 If the Sun were twice as massive its escape velocity would be higher (by a factor of about 1.4). Being in the same orbit, the Earth would see the same flux of solar radiation and therefore the temperature of the atmosphere would be about the same (ignoring greenhouse effects). The main consequence of this would be that the atmosphere would be denser or thicker than it is now. It is also likely that the Earth would have retained more of the light gases hydrogen and helium.

6.2 The peak wavelength of a blackbody is inversely proportional to its temperature. If the temperature were tripled, then the peak wavelength would go down by a factor of 3: $\lambda = 500/3\,\mathrm{nm} = 167\,\mathrm{nm}$. Likewise, if the temperature were halved, the peak wavelength would go up by a factor of 2: $\lambda = 500 \times 2\,\mathrm{nm} = 1000\,\mathrm{nm}$.

6.3 According to my reading of figure 7.8, the blackbody temperature would be about 180 K. Other factors that go into determining the surface temperature of the planet are (1) how much internal heat energy the planet has left over from its formation (accretional energy and radioactivity) and (2) how much of a greenhouse effect is occuring.

6.4 After 6 half-lives 1.6% of the original atoms are left, and after 7 half-lives only 0.78% would be left. So about 7 half-lives need to pass before 99% or more of the original atoms decay, which for ^{90}Sr would be 197 yrs.

6.5 Heat can flow through radiative transfer, conduction, and convection. In the first case energy is carried by electromagnetic radiation, in the second it is carried by atoms, ions, and molecules that collide with each other, and in the final case energy is carried by moving cells or pockets of gas or liquid. Examples include heating of the Earth by sunlight (radiative), hot filaments in a light bulb or electric stove (conduction), and heating of a room by radiators (convection) (the air by the radiator is heated and rises toward the ceiling while cooler air near the floor is drawn in toward the radiator; this sets up a gentle circulation pattern).