Physics 216 HW Ch19&20 due at the beginning of class 4/10/2017.

To receive full credit:

- **clearly show your reasoning** (including any necessary calculations),
- **indicate your final answer in an unambiguous way** (such as by circling or underlining it).
- **Round your answers appropriately**

1. Consider the thermal situation of a planet orbiting a star. To be specific, consider the earth orbiting our sun. The earth receives energy from the sun by radiation. The earth also loses energy by the process of radiation. If the earth is to be in steady state (average temperature not going up or down), these two energy transfers must balance. Below are a sequence of calculations that will let you determine the expected temperature of the earth in this model. Some relevant astronomical data is in the table in the inside back cover of your textbook.
    a. The power output of the sun is that of a black body radiator at a temperature of about 5600 K and an emissivity of 1. Determine the power emitted by the sun.
    b. How much solar radiant energy is incident on the earth? Imagine the sun radiates its power uniformly in all directions in space. At the distance from the sun of the earth's orbit, the sun's power is spread out over the area of a sphere whose radius is the radius of the earth's orbit. The fraction of that power incident on the earth is the fraction represented by the area of the disk of the earth (since that is what intercepts the power from the sun) to the area of that large sphere the size of earth's orbit. Given that and the fact that about 30% of the incident energy from the sun is reflected from the earth, determine how much solar radiated power is absorbed by the earth.
    c. If the earth is radiating because it has come to some temperature Te due to receiving radiation from the sun, determine an expression for the power radiated by the earth assuming it is a black body with emissivity 1. Note the full surface area of the sphere of the earth is the radiating area.
    d. Equate the expression for the power radiated by the earth (part c) with the numerical value for the power incident on the earth (part b) and determine the expected steady-state temperature of the earth.
    e. When we actually measure the average surface temperature of the earth, we get a considerably larger number. Find that value and cite a reference. This larger value is largely due to the effect of carbon dioxide (produced by plants) and other so-called greenhouse gases (water vapor, methane) which transmit visible sunlight but absorb the infrared radiation emitted thermally by the earth. The earth is in a relative sweet spot in that regard: Too much CO2 can lead to the "run-away greenhouse effect", as on Venus where surface temperatures exceed the melting point of lead. In contrast, for Mars suffers from the "runaway ice-house effect" where too little CO2 and feebler sunlight at the orbit of Mars cause the water vapor to freeze out, reducing greenhouse warming even more.

(over)

2. For the distribution below, determine the most probably result, the mean (average) result and the median (the result where ½ the results are above that value, and half are below). Be sure to show all work.