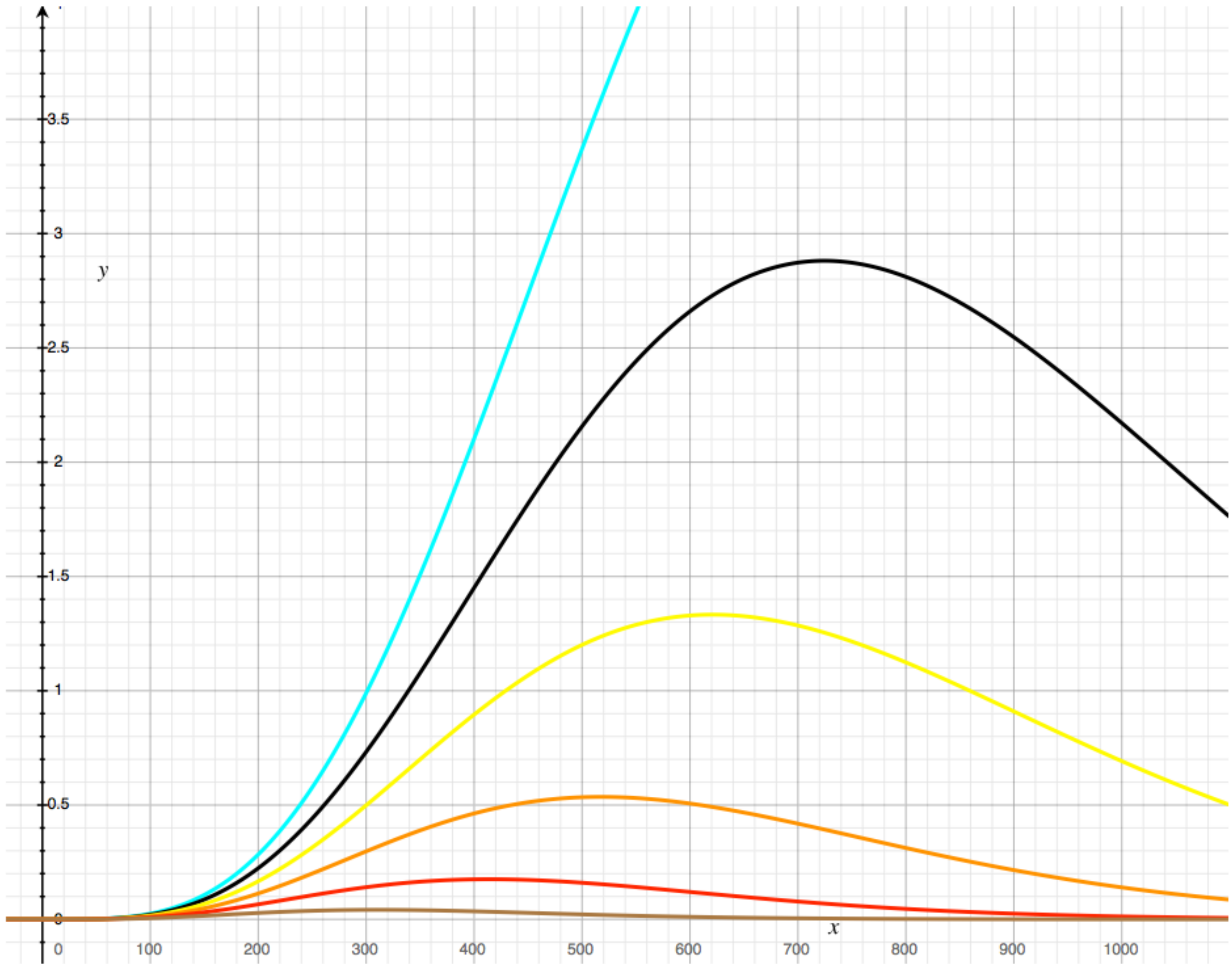
Blackbody Radiation and Wein's Law

The purpose of this worksheet is for you to learn about the properties of blackbody radiation by studying a graph of intensity versus frequency. Each of the curves on the graph represents the radiation that would be emitted by an object with a certain temperature. For an interactive Desmos version of the graph go to: https://www.desmos.com/calculator/juv2g2ufue.

1. Start by labeling each axis on the graph: The *x*-axis represents frequency in terahertz (THz). 1 THz = 10^{12} Hz. This is the frequency of electromagnetic radiation. The *y*-axis represents relative intensity in millions of Joules per meter^4 (MJ/m^4). This value basically indicates the "strength" or "amount" of EMR emitted at any given frequency.
2. Use the slider in Desmos to observe the effect on changing temperature. Use this tool to determine the temperature corresponding to each curve shown on printed graph. Label each blackbody curve on your paper with the correct temperature in kelvin.
3. Let's look at one curve just to illustrate its meaning. Use the curve for a temperature of 6000 K, which is just a bit hotter than the surface of the Sun but close to the same. You may want to use Desmos to trace along the curve.
   (a) At 6000 K determine the relative intensity of EMR given off at a frequency of 500 THz.
   (b) At 6000 K find a *second* frequency at which the intensity is the *same* as it is at 500 THz.
   (c) At 6000 K determine the maximum intensity and the "peak frequency" at which it occurs.
4. To make the graph more meaningful label the ranges of frequencies corresponding to the infrared, visible, and ultraviolet. The approximate ranges: Infrared – from 1 to 400 THz; Visible – from 400 THz to 750 THz; Ultraviolet – from 750 THz to 100000 THz.
5. Also label approximate ranges for the colors ROYGBV giving each color an approximately equal range (or "width") of frequencies in the visible portion of the graph. Click on the circle labeled "ROGBV" in Desmos to show this!
6. Wein's Law allows one to quickly calculate the peak wavelength for a given temperature and vice versa. Use Wein's Law to calculate the peak wavelength for all six temperatures shown on the graph and then use the equation $v = f\lambda$ to find the peak frequency. The values for peak frequency should match what is shown by the graph – does it? Optional challenge: determine a single equation (your "own law") that relates temperature to peak frequency.
7. In what range of temperatures is red emitted at greater intensity than violet? In what range of temperatures is violet emitted at greater intensity than red?
8. At what temperature would an object emit "white light"?
9. At which of the given temperature curves would there be the greatest amount of infrared emitted? How about ultraviolet?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