Sanjali Sur

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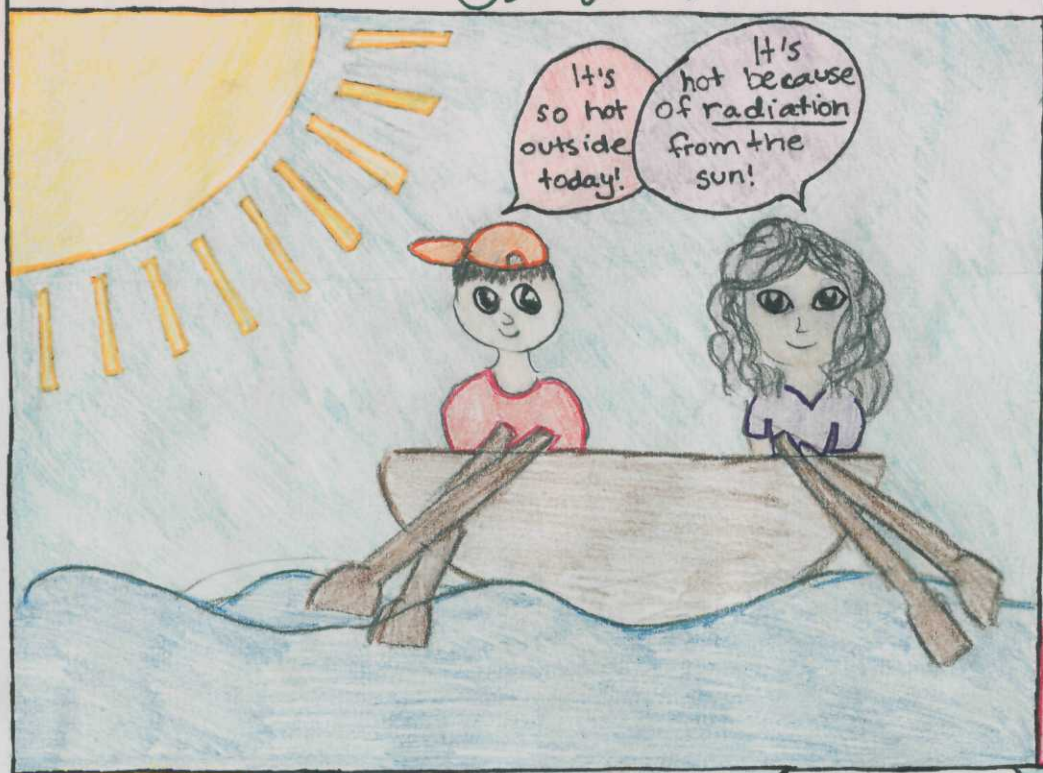
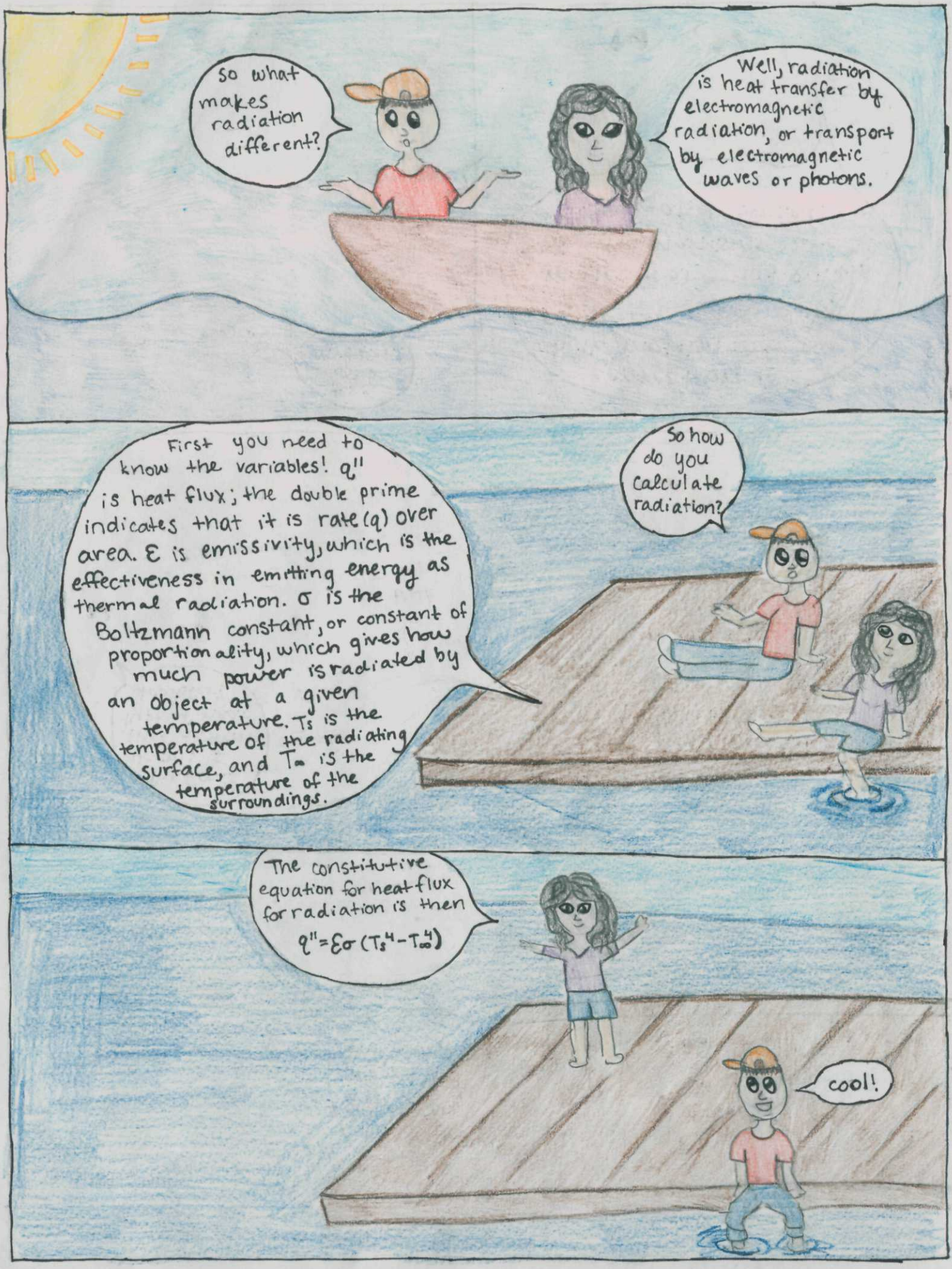
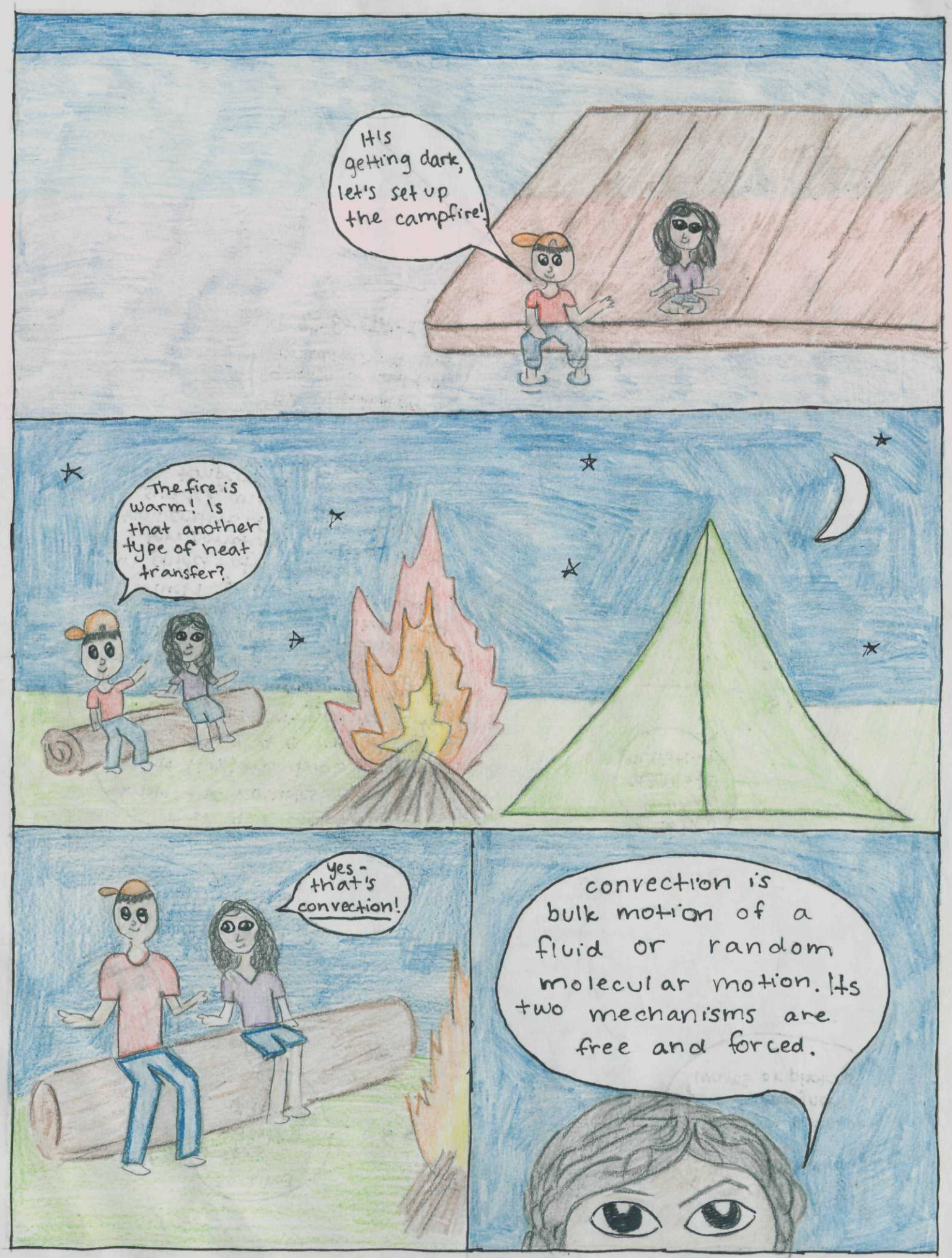
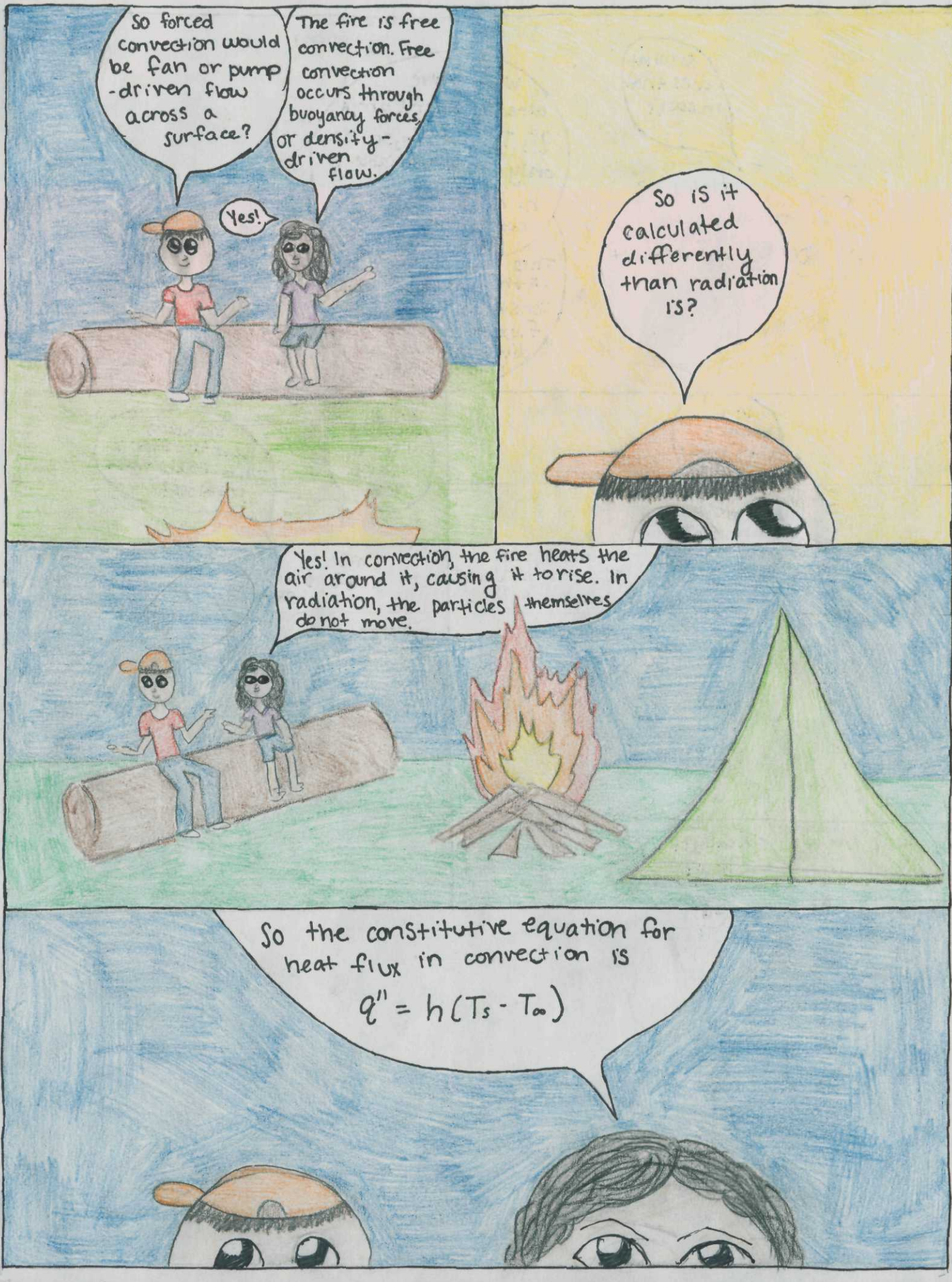
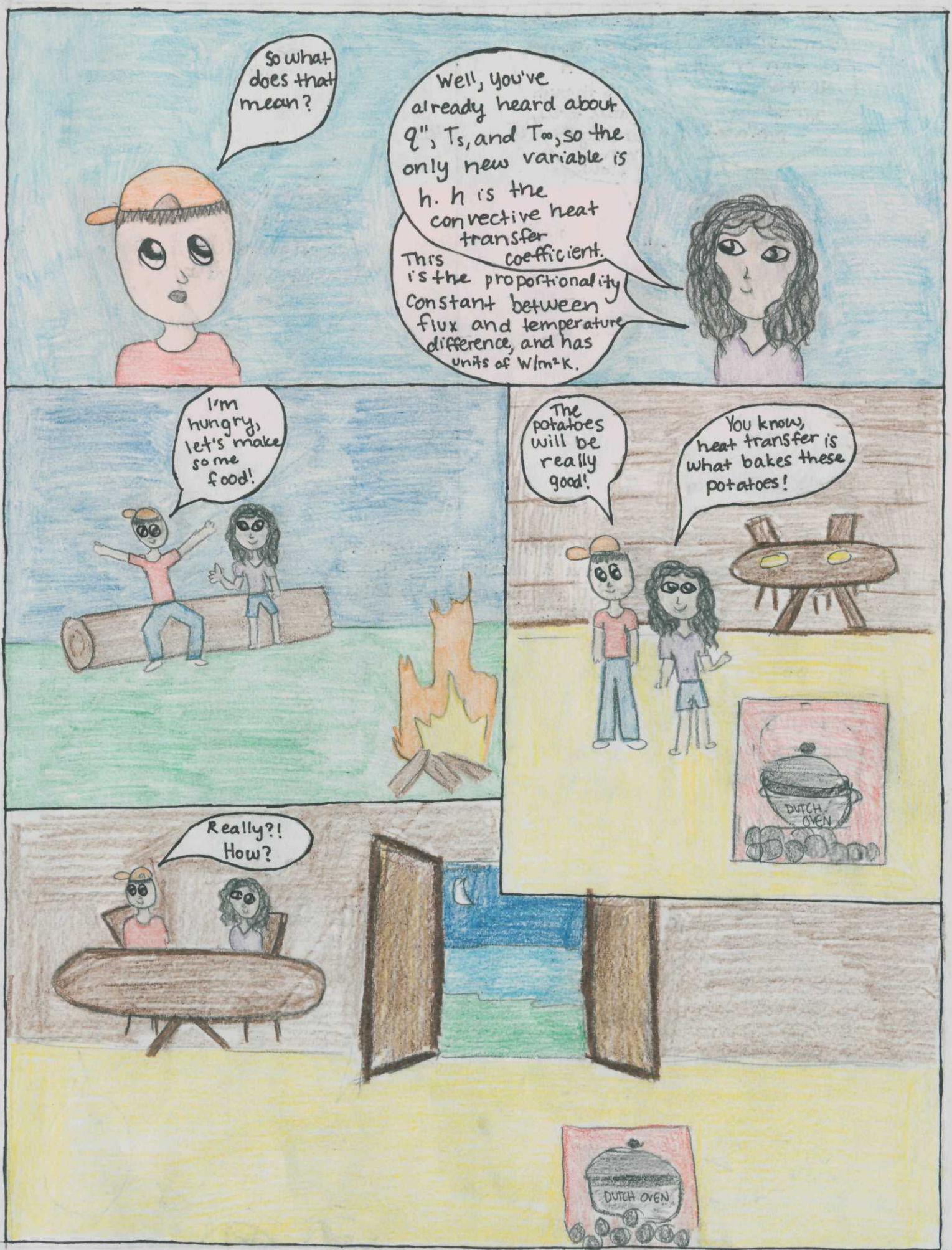
CHEMICAL ENGINEERS CAMP

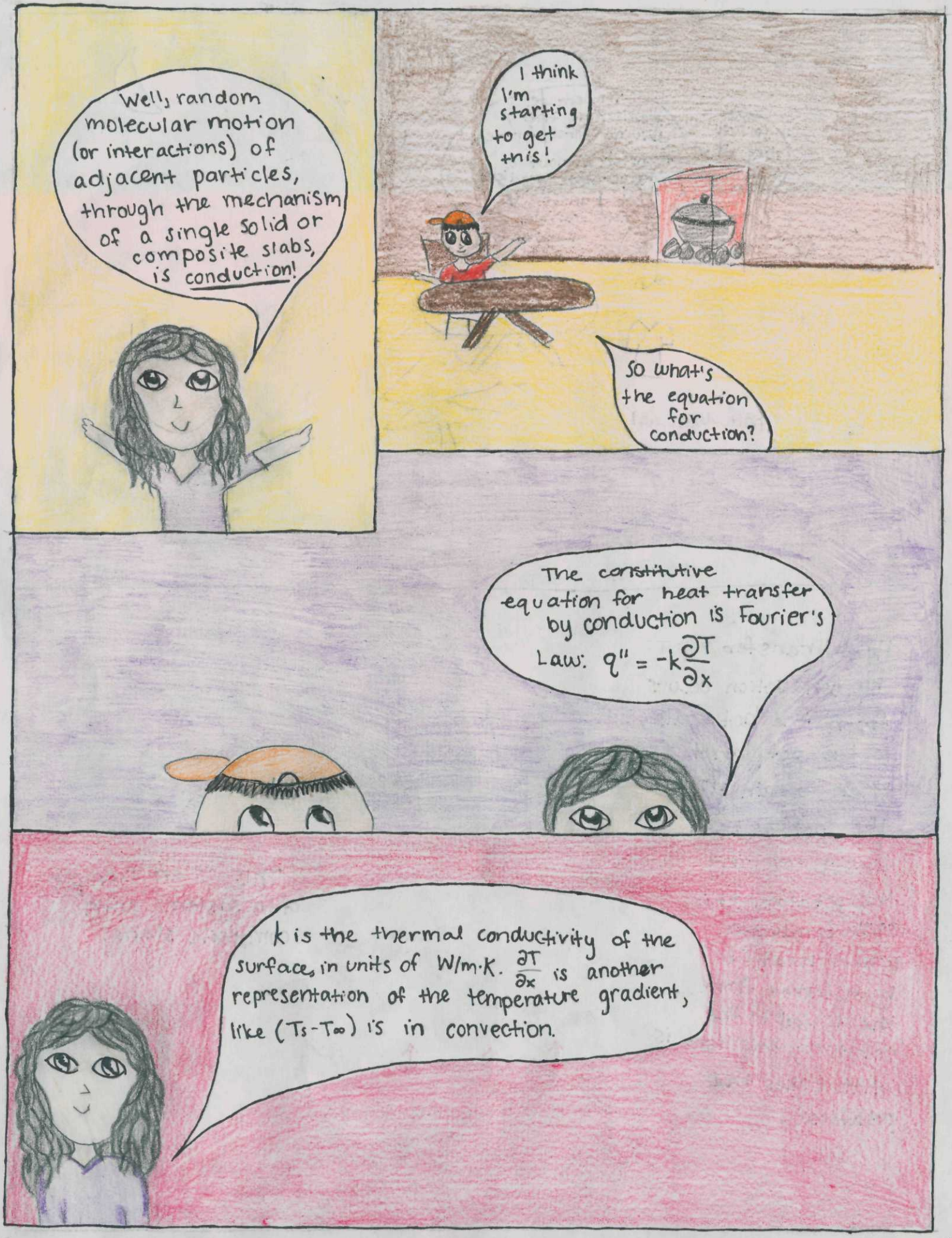



So what makes radiation different?
Well, radiation is heat transfer by electromagnetic radiation, or transport by electromagnetic waves or photons.
First you need to know the variables! q'' is heat flux; the double prime indicates that it is rate (q) over area. ε is emissivity, which is the effectiveness in emitting energy as thermal radiation. σ is the Boltzmann constant, or constant of proportionality, which gives how much power is radiated by an object at a given temperature. T_s is the temperature of the radiating surface, and T_∞ is the temperature of the surroundings.
So how do you calculate radiation?
The constitutive equation for heat flux for radiation is then
$q'' = \varepsilon\sigma(T_s^4 - T_\infty^4)$
cool!

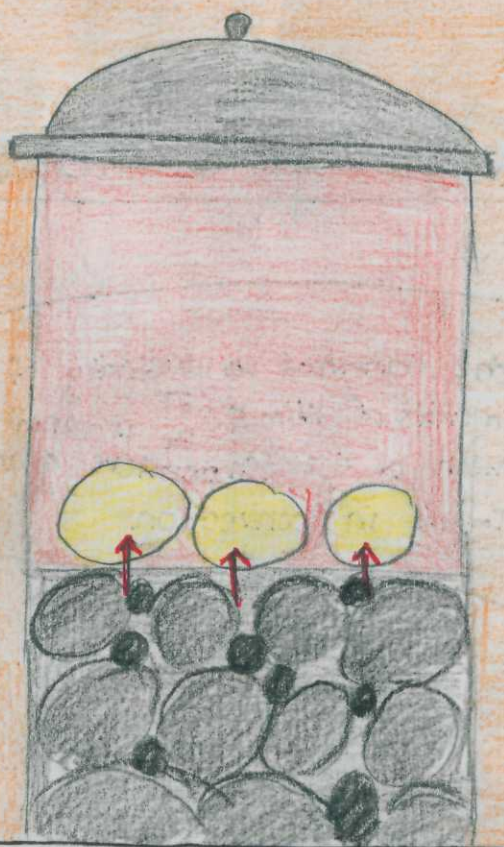

It's getting dark, let's set up the campfire!
The fire is warm! Is that another type of heat transfer?
yes - that's convection!
convection is bulk motion of a fluid or random molecular motion. Its two mechanisms are free and forced.


So forced convection would be fan or pump -driven flow across a surface?
The fire is free convection. Free convection occurs through buoyancy forces, or density-driven flow.
Yes!
So is it calculated differently than radiation is?
Yes! In convection, the fire heats the air around it, causing it to rise. In radiation, the particles themselves do not move.
So the constitutive equation for heat flux in convection is
$q'' = h(T_s - T_\infty)$


So what does that mean?
Well, you've already heard about q", Ts, and T∞, so the only new variable is h. h is the convective heat transfer coefficient.
This is the proportionality constant between flux and temperature difference, and has units of W/m²K.
I'm hungry, let's make some food!
The potatoes will be really good!
You know, heat transfer is what bakes these potatoes!
DUTCH OVEN
Really?! How?
DUTCH OVEN


I think I'm starting to get this!
So what's the equation for conduction?
Well, random molecular motion (or interactions) of adjacent particles, through the mechanism of a single solid or composite slabs, is conduction!
The constitutive equation for heat transfer by conduction is Fourier's Law: $q'' = -k\frac{\partial T}{\partial x}$
k is the thermal conductivity of the surface, in units of W/m·K. $\frac{\partial T}{\partial x}$ is another representation of the temperature gradient, like $(T_s - T_\infty)$ is in convection.

Heat transfer by conduction occurs from the hot coals to the pot, and then again from the pot to the tinfoil covering the potatoes. It is still conduction when heat is transferred from the tinfoil to the potatoes; this heat is what bakes the potatoes.



This is an example of a system with composite slabs.

So let's recap! Temperature gradient is what drives heat transfer.

Conduction, or random molecular motion of adjacent particles, is described by Fourier's Law $q'' = -k \frac{\partial T}{\partial x}$

Convection, bulk motion of a fluid, can be free or forced, and is expressed by $q'' = h(T_s - T_\infty)$

Radiation is heat transfer caused by electromagnetic waves or photons, and is $q'' = \varepsilon\sigma(T_s^4 - T_\infty^4)$

Now you know all about heat transfer!

Awesome!

THE END