Activity 21.10.1.

Hopefully, here are some of the things you noticed or concluded from drawing your equipotential surfaces.

- **a.** A circle in two dimensions is a sphere in three dimensions.
- **b.** A line in one dimension is a flat sheet in two dimensions.
- **d.** The equipotential (constant potential) surfaces are always perpendicular to the electric field lines at every point in space.
- **d.** The equipotential surfaces are denser (smaller spacing between surfaces) in the same regions that the electric field lines are denser.

Note that when we say equipotential "line" or electric field "line", we are being a bit loose with our wording. The "lines" can definitely be curved.

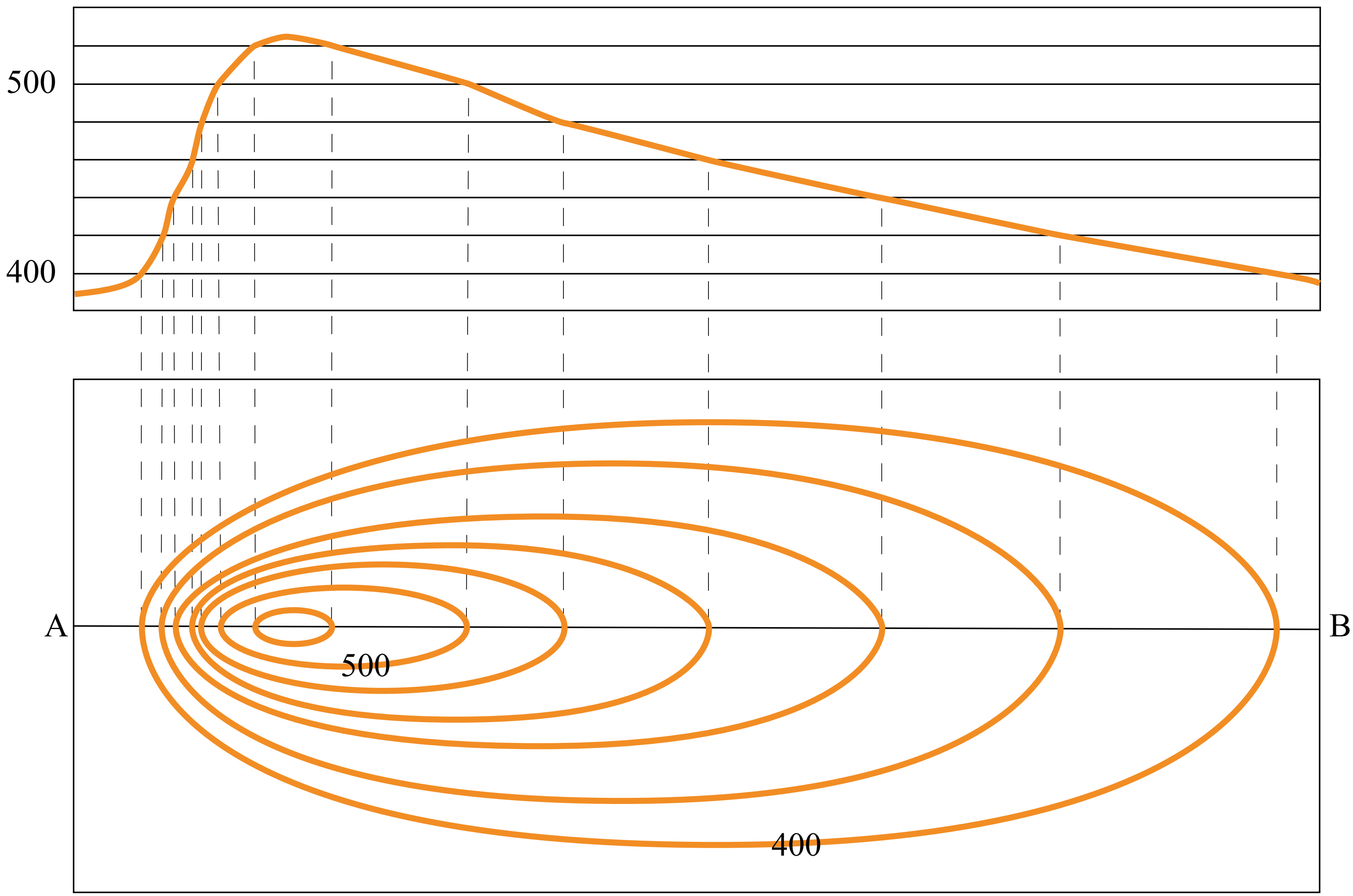
Activity 21.11

Before we start on Activity 21.11.1, let's just spend a little bit of time interpreting how to read our equipotential surfaces for a particular charge configuration.

Since the concepts of force, potential, and potential energy are so similar for electrical and gravitational, we can use concepts we developed for one to help us with the concepts for the other.

Electric equipotential surfaces are very much like the contour lines we draw for a topographical map. Just like the contour lines show locations of the same elevation above sea level, equipotential surfaces show locations of the same potential.

The lower image on the next page shows a simple contour map. The upper image shows the profile of the landscape if we were to slice the contour map from point A to point B (looking from the side instead of from above).

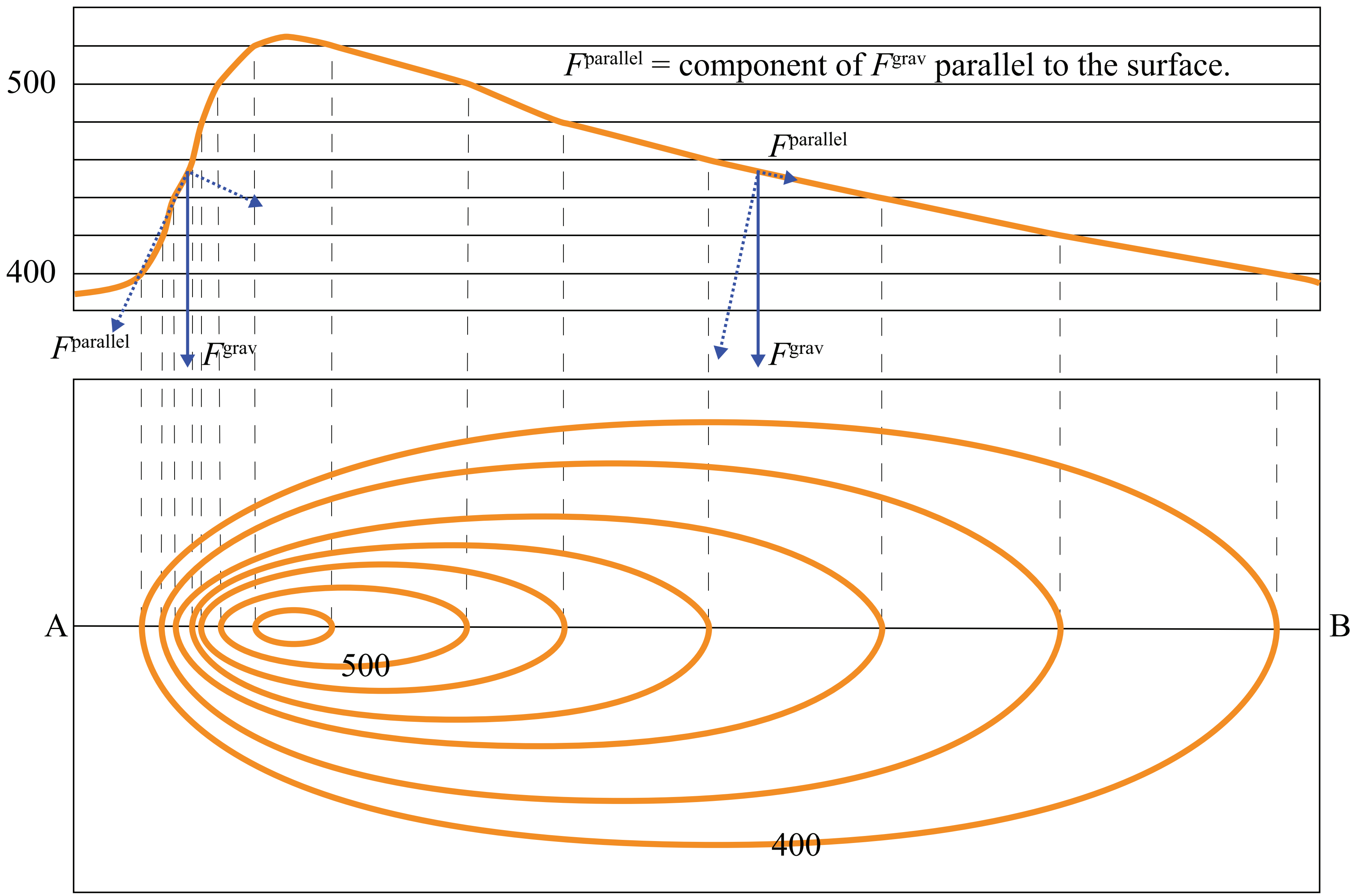

500
400
A
B
500
400

Our “mountain” is steep where the contour lines are more dense (the left side), and has a gentle slope where the contour lines are less dense (the right side).

If we were to let go of a ball on the side to the left of the mountain peak (where the contour lines are more dense), it will pick up speed very quickly. This is because the component of the gravitational force (field) parallel to the surface has a large magnitude, as shown in the image on the next page.

If we were to let go of a ball on the side to the right of the mountain peak (where the contour lines are less dense), it will not speed up nearly as quickly. This is because the component of the gravitational force (field) parallel to the surface has a small magnitude.

Similarly, the electric field has a large magnitude where the equipotential lines are more dense (steeper slope), and the electric field has a small magnitude where the equipotential lines are less dense (shallower slope).

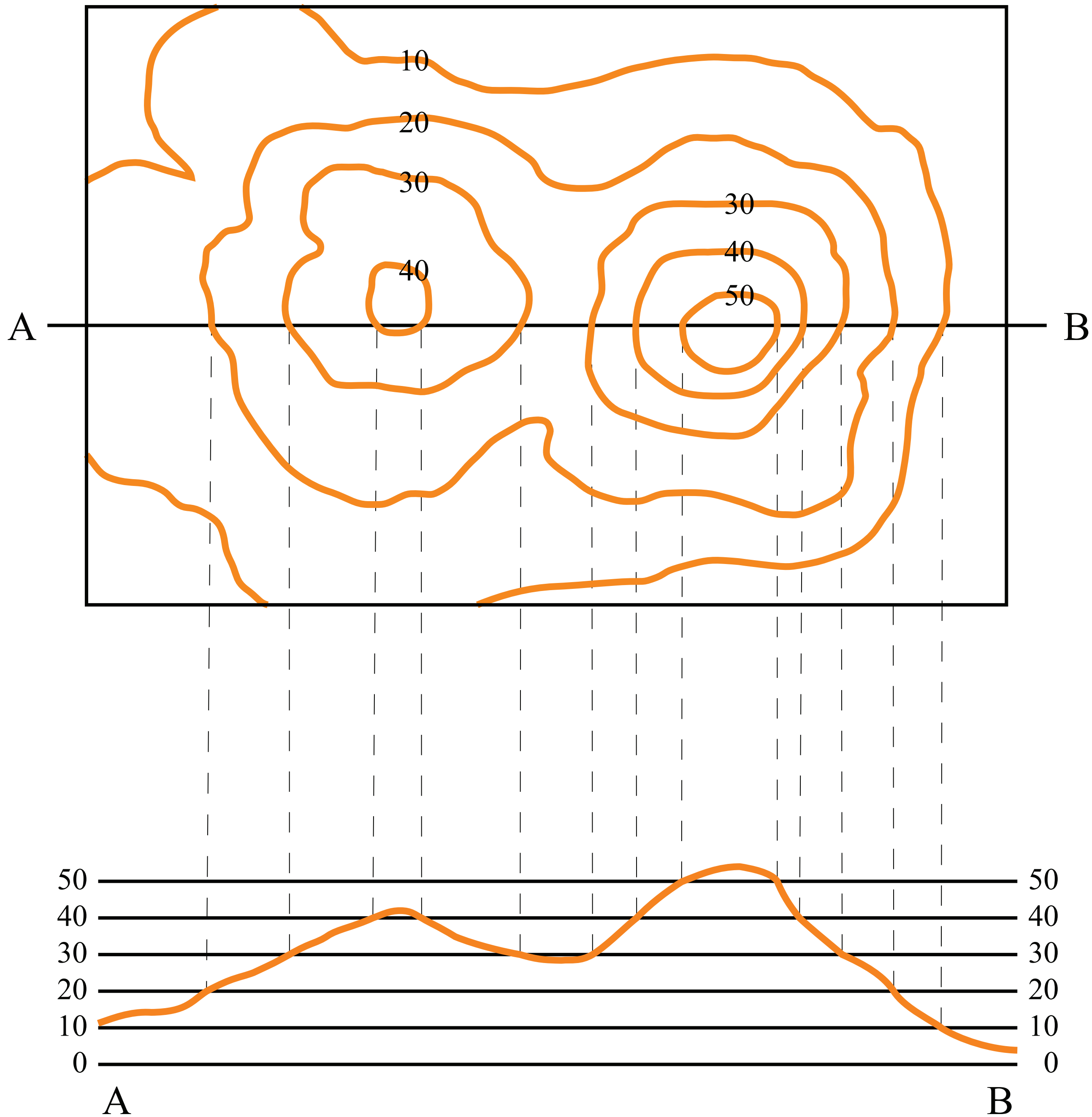


$F^{parallel}$ = component of F^{grav} parallel to the surface.
500
400
$F^{parallel}$
F^{grav}
$F^{parallel}$
F^{grav}
A
B
500
400

The upper image on the next page shows a contour map that is a little more complex, with a profile for the A–B slice shown in the lower image. Notice that there are 2 different contour lines for an elevation of 30 m above sea level, and 2 different contour lines for an elevation of 40 m above sea level. Our electric equipotential maps could certainly have the same situation.

While the two contour map examples I’ve shown have only elevations above sea level (positive values), we certainly can have contour maps with elevations below sea level (negative values) – Death Valley for example. Our electric equipotential maps will also have equipotential surfaces with both positive and negative voltage values.

For our analogy, positive charges are where mountain peaks would be, and negative charges are where valleys below sea level would be. The more charge at a location, the higher the peaks or deeper the valley.


10
20
30
40
30
40
50
A
B
50
40
30
20
10
0
A
B