Electric Potential Example

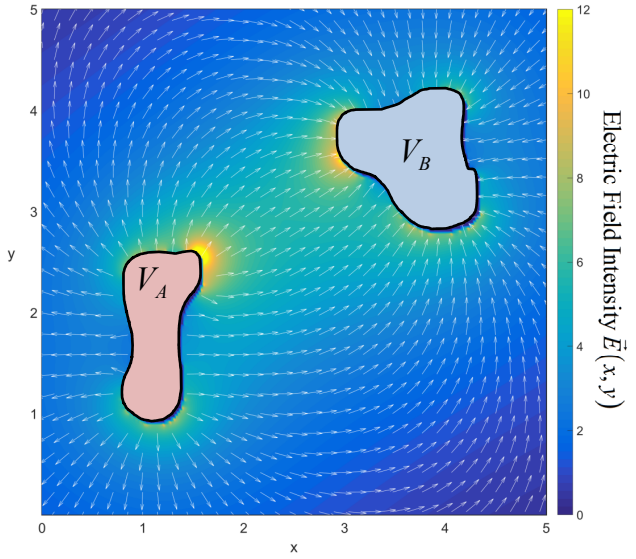
EE3321

Electromagnetic Field Theory

Example Setup

What is the potential difference between these objects?

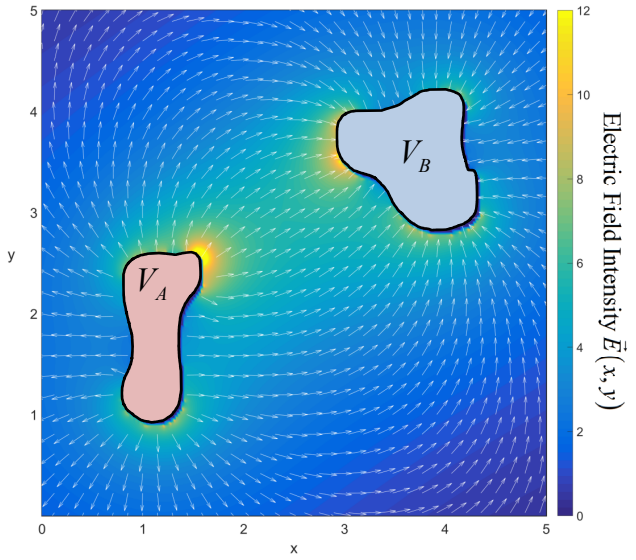
$$V = V_B - V_A$$



Solution (1 of 8)

We calculate V from E using a line integration.

$$V = V_B - V_A = -\int_A^B \vec{E} \bullet d\vec{\ell}$$



Solution (2 of 8)

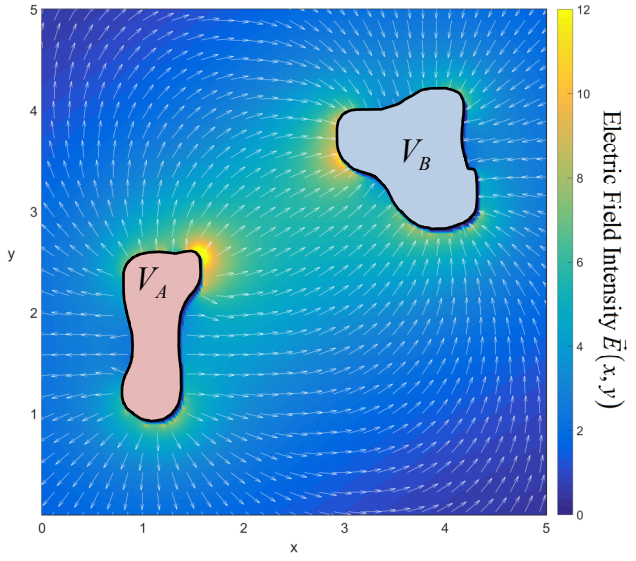
We calculate V from E using a line integration.

$$V = V_B - V_A = -\int_A^B \vec{E} \bullet d\vec{\ell}$$

For easy integration, we pick a path where the electric field is in the straightest line.

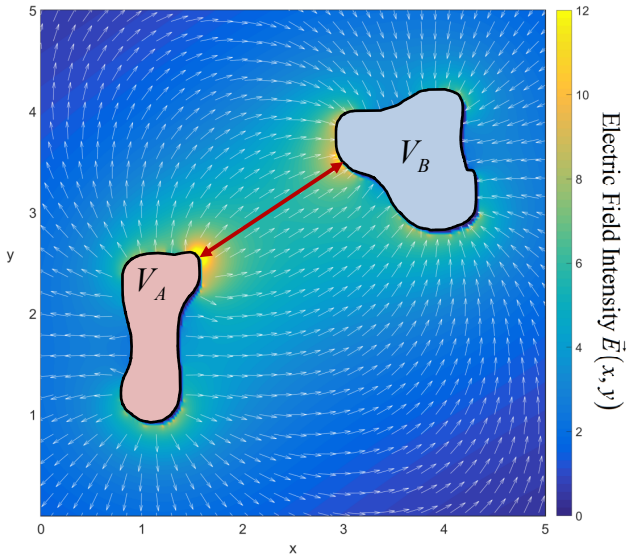
This will simplify our dot product to

$$\vec{E} \bullet d\vec{\ell} \approx \left|\vec{E}\right| d\ell$$



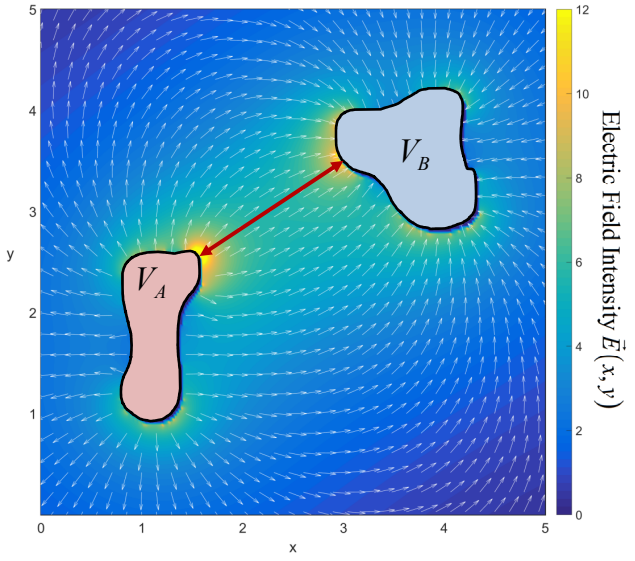
Solution (3 of 8)

How about this path?



Solution (4 of 8)

From the figure, we can see that the electric field is almost constant along this path.



Solution (5 of 8)

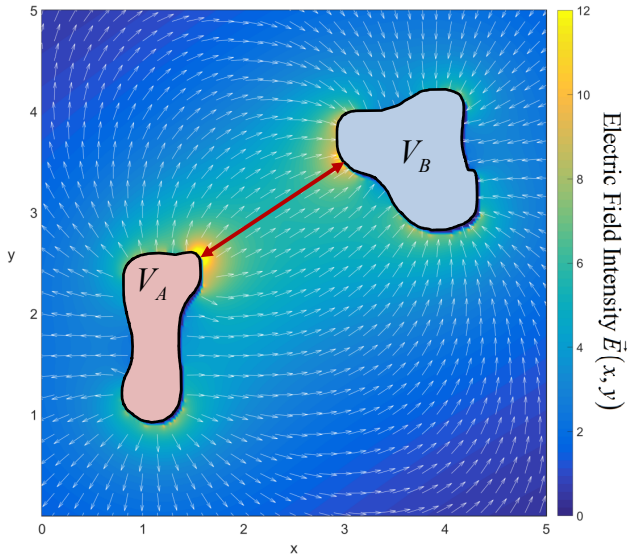
From the figure, we can see that the electric field is almost constant along this path.

This let's us approximate the integral as

$$V = -\int_A^B \vec{E} \bullet d\vec{\ell}$$

$$\approx -\int_A^B \left|\vec{E}\right| d\ell$$

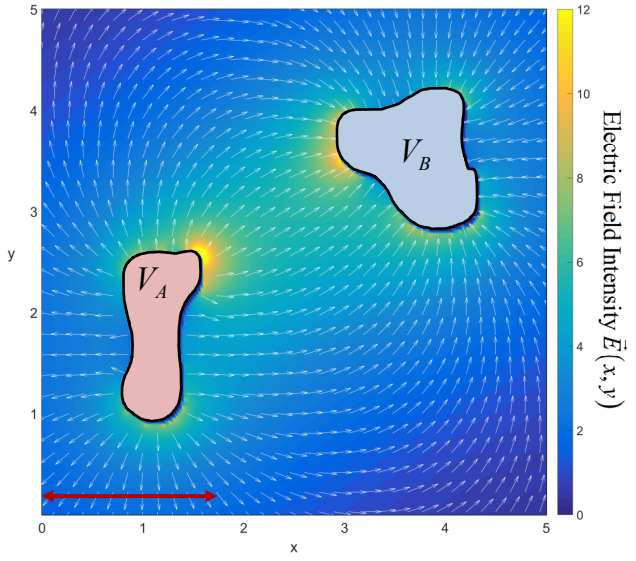
$$\approx -\left|\vec{E}\right| L$$



Solution (6 of 8)

To estimate L, we move the line down to the x-axis.

$$L \approx 1.7$$



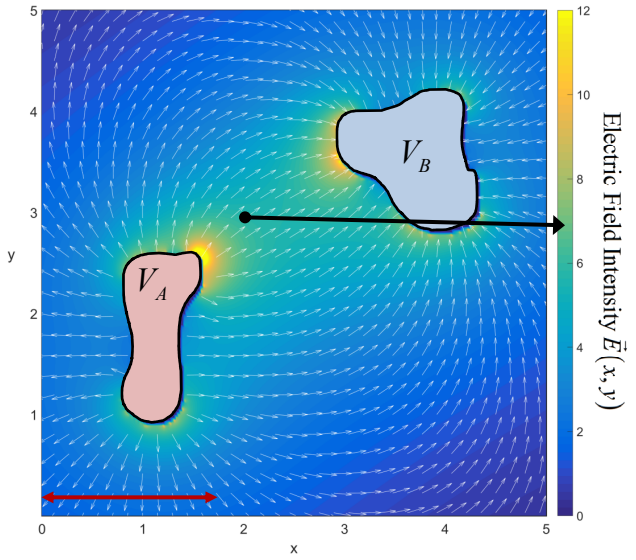
Solution (7 of 8)

To estimate L, we move the line down to the x-axis.

$$L \approx 1.7$$

To estimate $|E|$, we read the color from the color bar.

$$\left|\vec{E}\right| \approx 7.0$$



Solution (8 of 8)

To estimate L, we move the line down to the x-axis.

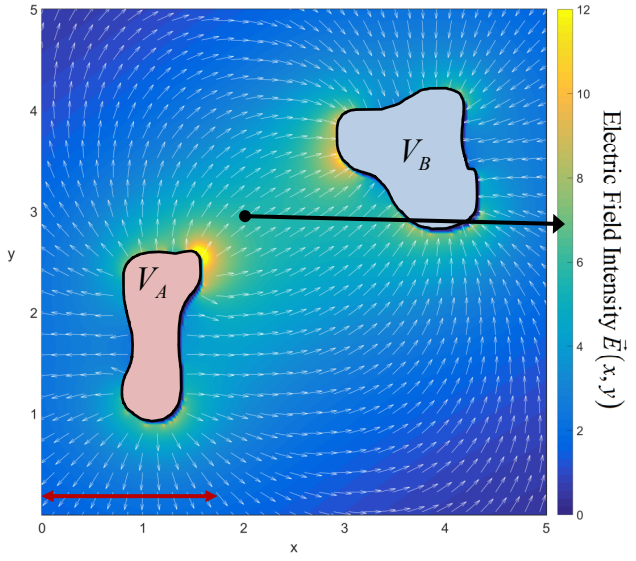
$$L \approx 1.7$$

To estimate $|E|$, we read the color from the color bar.

$$\left|\vec{E}\right| \approx 7.0$$

Finally, the potential difference V is approximately

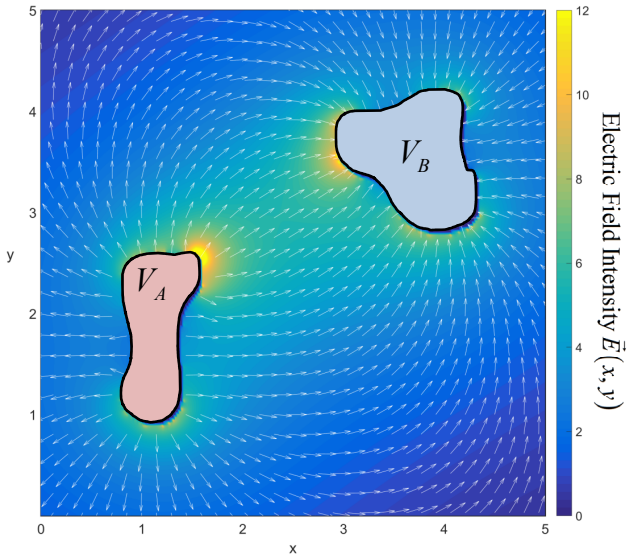
$$V = -\left|\vec{E}\right| L$$
$$= -(7.0)(1.7)$$
$$= \boxed{-11.9 \text{ V}}$$



Interpreting the Sign (1 of 2)

Why do we have a negative voltage?

$$V = -11.9 \text{ V}$$



Interpreting the Sign (2 of 3)

Why do we have a negative voltage?

$$V = -11.9 \text{ V}$$

Recall our definition of V.

$$V = V_B - V_A = -\int_A^B \vec{E} \bullet d\vec{\ell}$$

We can see from the figure that

$V_A > V_B$

Therefore

$V = V_B - V_A$ is negative.