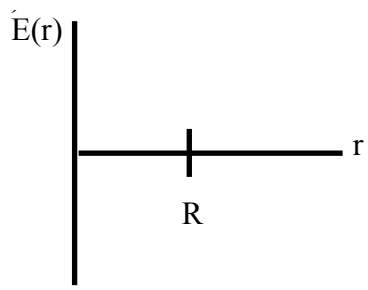
10/2 More on Electric Potential

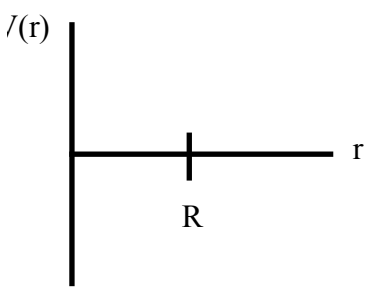
These are best done in order!

On exam 1, you showed that, for a uniformly charged, solid sphere of radius R and total charge q, the Electric field is: (Actually I gave you ρ instead of q.)

$$\vec{E} = \begin{cases} \dfrac{kq\vec{r}}{R^3} & \text{for } r < R \\ \dfrac{kq}{r^2}\hat{r} & \text{for } r > R \end{cases}$$

1. Find $V(r)$ outside the sphere, using ∞ as your reference point.
2. Find $V(r)$ inside the sphere, using ∞ as your reference point.
3. Sketch $E(r)$ and $V(r)$





4. Repeat the last three problems, except this time, use the origin as your reference point for $V(r)$. It's easier to start with the inside case now. (Do both, find $V(r)$ inside and outside, and the sketch.)
5. The two different choices of reference point should yield two different (sets of) $V(r)$'s. How are they different? Why is this okay? Or is it okay?

Last time in class, you derived V for point charges and you got:

$$V = k\frac{q}{\mathscr{r}}$$

with a reference point at ∞ It probably will not surprise you that you can use the principle of superposition if you have more than one source charge, q.

6. Two charged point particles are on the x-axis. $q_1 = 5\text{nC}$ and is located at the origin. $q_2 = 5\text{nC}$ and is located at $x = 6m$. (Throughout this problem I ask for variables and numbers. So, you might do (a) and (b) basically at the same time.)

   (a) What is the electric potential at the midpoint between the two charges, $x = 3\text{m}$?

   (b) Repeat this part with variables only in your answer, so q and x where x is the coordinate of the point where you find V. (Your answer will also have a k or ϵ_0).

   (c) What is the electric potential at $x = 12\text{m}$?

   (d) Repeat this part with variables only in your answer, q and x where x is the coordinate of the point where you find V. (Your answer will also have a k or ϵ_0).

   (e) What is the electric potential 4m directly above the midpoint of the two charges, at $(x, y) = (3, 4)m$?

   (f) Repeat the last part with only variables: q, x, y where x and y are the coordinates of the point where you find V. (Your answer will also have a k or ϵ_0).

7. Two charged point particles are on the x-axis. $q_1 = 5\text{nC}$ and is located at the origin. $q_2 = 5\text{nC}$ and is located at $x = 6m$.

   (a) What is the electric field at the midpoint between the two charges, $x = 3\text{m}$?

   (b) If you got zero, nothing to write here. (Just a placeholder for symmetry).

   (c) What is the electric field at $x = 12\text{m}$?

   (d) Repeat this part with variables only in your answer, q and x where x is the coordinate of the point where you find V. (Your answer will also have a k or ϵ_0).

   (e) What is the electric field 4m directly above the midpoint of the two charges, at $(x, y) = (3, 4)m$?

   (f) Repeat the last part with only variables: q, x, y where x and y are the coordinates of the point where you find $\vec{E}$. (Your answer will also have a k or ϵ_0).

8. Is there any contradiction between 6a,b and 7a,b? Explain your answer.

9. Integrate the appropriate $\vec{E}$ from problem 7 to get the answers to 6b and 6f. (This should only involve a change in limits.)

10. Now integrate the appropriate $\vec{E}$ – you will have to edit a bit from problem 7, to be able to get 6d.

11. It should also work the other way. Can you take the negative gradient of 6f to get 7f?

12. Can you take the negative gradient of 6d to get 7d?