Calculating Electric Potential

PHY 114-01

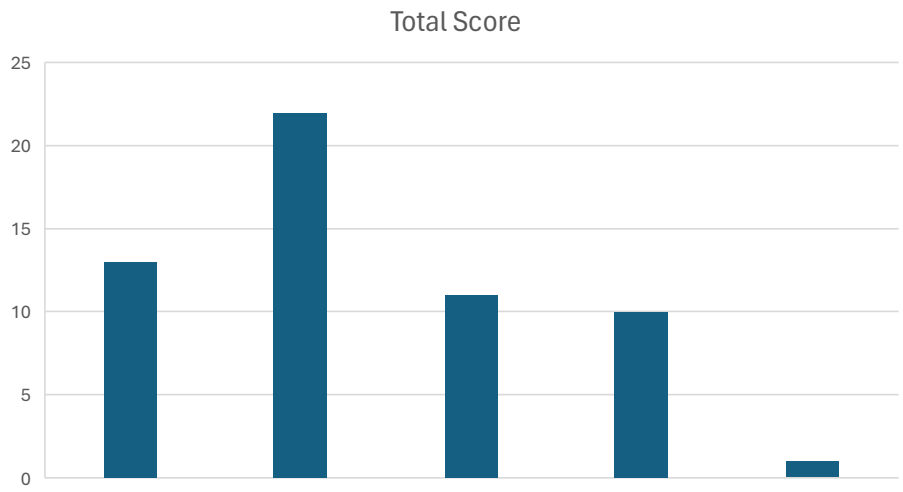
Fall 2026

Announcements

- HW4 due Friday 11:59pm
- Midterm 1 grades released

Midterm 1 results

Mean: 47.94%
Stdv: 21.98



Main takeaways:

- Most common error: choosing the wrong method
- Multiple choice reveals low conceptual understanding (matches most common quantitative error)

Exam Reflections Midterm 1

Due Monday 10/19 11:59pm
on gradescope

- Earn up to 20 points back on Midterm 1 by submitting a reflection

- Conceptual problems:
  - Select the correct answer
  - Explain the mistakes in your previous answer (1-2 sentences and necessary equations)
  - Justify your new answer (1-2 sentences and necessary equations)
  - 1 point per part above

- Quantitative problems:
  - Explain the mistake you made in your original solution (2-3 sentences and necessary equations)
  - Present a new solution with your work clearly shown and explained
  - Up to 5 points per part above

Path to passing

- You got 40% on Midterm 1
- You get 20 points back through your exam reflection

- You get 70% on Midterm 2

- You get 80% on the Final

- You get close to 100% on the homework, labs, and participation.

- $0.2 (0.6 + 0.7) + 0.25 (0.8) + 0.15 (1) + 0.1 (1) + 0.1 (1) = 0.81$

Midterm 1 difficulty

- Seems like you were not expecting Midterm 1.
- I have not set expectations correctly.

- However, this is the standard that I want you to reach this semester. And you can!
- Symbolic reasoning and variable manipulation is one of the main learning goals. You MUST solve problems symbolically to do physics.
- Now you know what to expect for next time.

Changes for next exam

Problems for me to solve:

- Multiple choice does not give enough opportunity for partial credit
  - Next exam will have T/F with justification conceptual questions
- Homework scores do not reflect understanding of material
  - I need to assign more homework
  - Optional problems from textbook that better reflect exam-style questions

Problems for you to solve:

- Go to class.
- Homework scores do not reflect understanding of material
  - Solve problems symbolically before plugging in numbers
  - You should be able to do them without multiple attempts
  - You should spend time on them yourself before asking for help or looking at references
- Go to recitation. TAs will show you how to solve problems like the exam.
- Come to office hours. I don’t bite.

Agenda

- Last time:
  - Defining electric potential

- This time:
  - Relationship between electric field and electric potential
  - Calculating electric potential

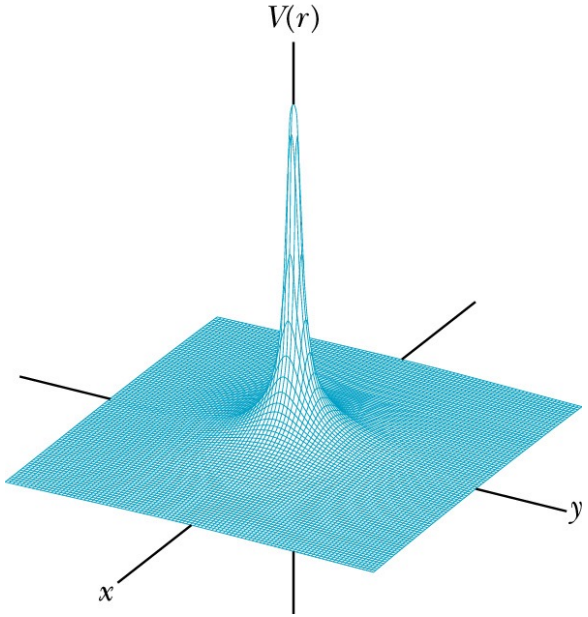
Absolute Potential

- **We can talk about the absolute potential due to a charge when we define**

$$V_\infty = 0$$

Absolute Potential $V(r)$ at any point

$$V(r) = k\frac{q}{r}$$



Potential $V(r)$ due to a point positive charge

The sign of V is the same as the sign of q

- **positive charges produce a positive potential**
- **negative charges produce a negative potential**

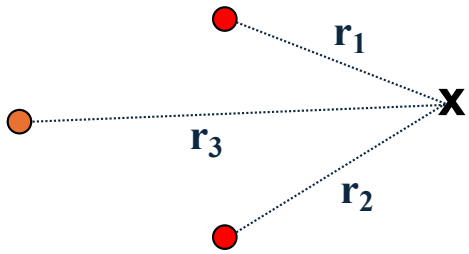
Potential for a distribution of charges

- Option 1: use superposition!
  - Add up the potential contribution from each individual point charge

- Example: potential of square of point charges
- Example: ring of uniform charge potential

Potential due to Many Charges: Superposition

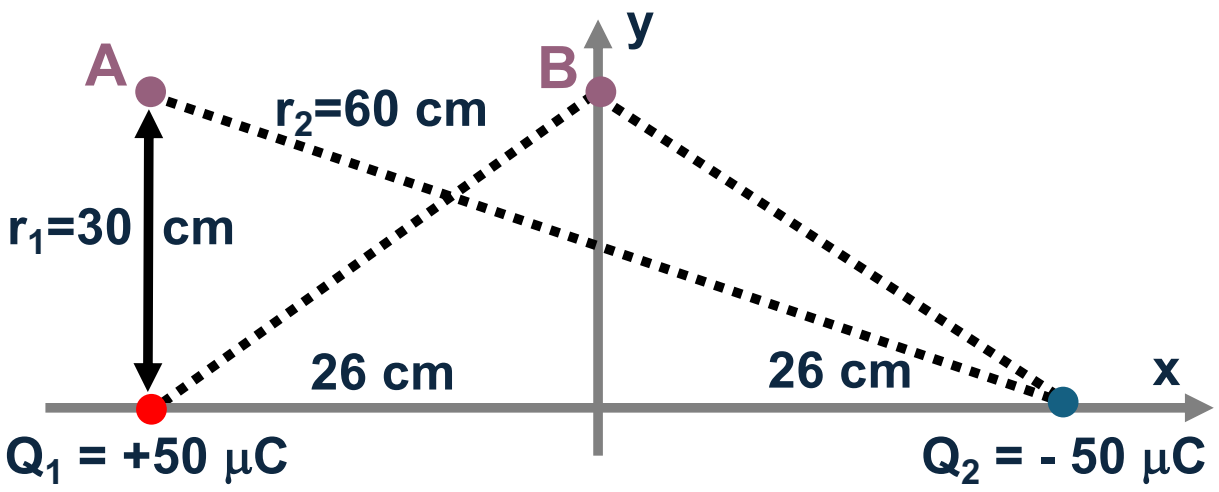
- **If there are several charges, the total potential at some point in space is the *scalar sum* of the potential from each charge.**
  - **For *n* point charges the net potential V is:**



$$V = \sum V_i = k\sum_{i=1}^{n} \frac{q_i}{r_i}$$

- **Since potential is a scalar, we only have to take care of the sign of the potential (unlike electric field, vector)**

ConceptCheck Electric Potential



The electric potential at point A is:

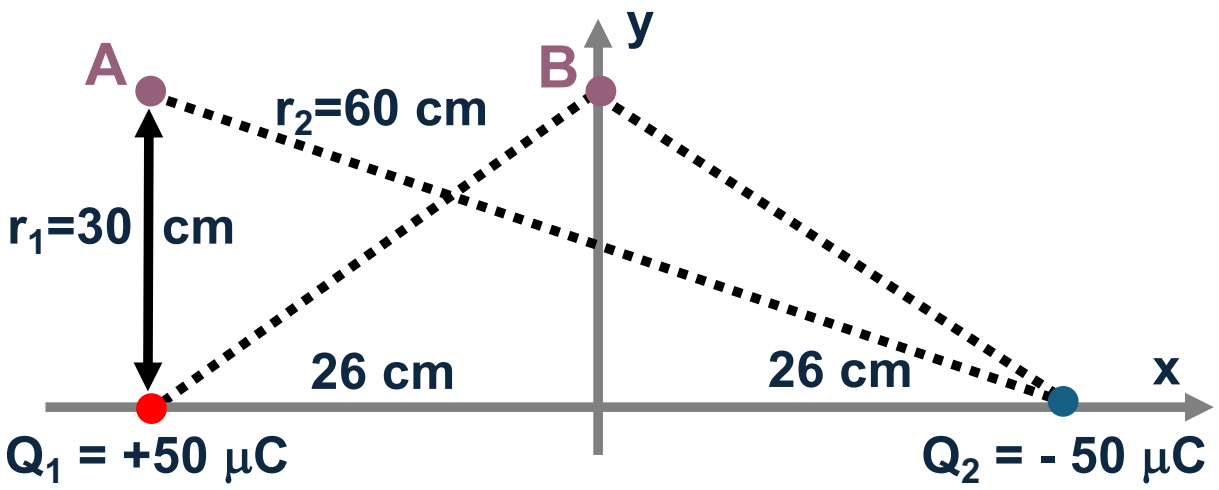
A. V > 0

B. V < 0

C. V = 0

$r_1 < r_2$, so $|V_1| > |V_2|$

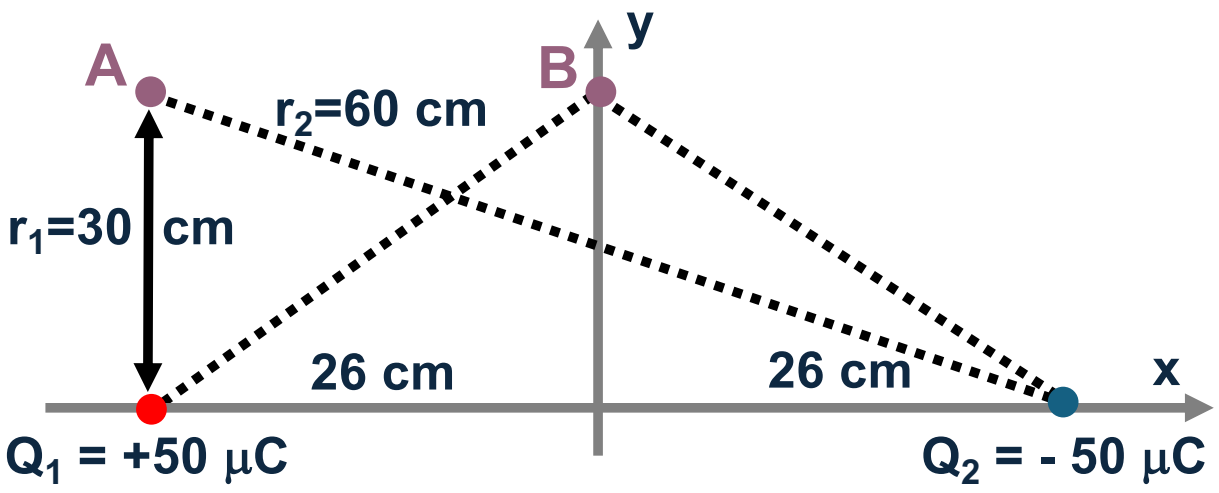
ConceptCheck Electric Potential Energy



Numerically, $$V = \sum V_i = k\sum_{i=1}^{n} \frac{q_i}{r_i} = k\left(\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right)$$

$$V = 9\times10^{9} \times 50\times10^{-6} \times \left(\frac{1}{0.3} - \frac{1}{0.6}\right) = 7.5\times10^{5}\,\text{V}$$

ConceptCheck Electric Potential



The electric potential at point B is:

A. V > 0

B. V < 0

C. V = 0

V=0 since Q_1 is positive, Q_2 negative, and they have equal distances

Electric field and electric potential

- If electric potential energy is $U = -\int q\vec{E} \cdot d\vec{x}$

- Then electric potential is $V = -\int \vec{E} \cdot d\vec{x}$

$$E = -\vec{\nabla}V$$

$$\vec{\nabla} = \frac{\partial}{\partial x}\hat{x} + \frac{\partial}{\partial y}\hat{y} + \frac{\partial}{\partial z}\hat{z}$$

cartesian

$$\vec{\nabla} = \frac{\partial}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial}{\partial \phi}\hat{\phi} + \frac{\partial}{\partial z}\hat{z}$$

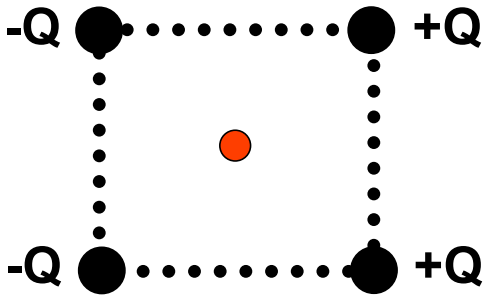
cylindrical

$$\vec{\nabla} = \frac{\partial}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial}{\partial \theta}\hat{\theta} + \frac{1}{r\sin\theta}\frac{\partial}{\partial \phi}\hat{\phi}$$

spherical

ConceptCheck Electric Field and Potential

Four charges are arranged at the corners of a square. Find the electric field E and the potential V at the center of the square.



A. $E = 0$ $V = 0$

B. $E = 0$ $V \neq 0$

C. $E \neq 0$ $V \neq 0$

D. $E \neq 0$ $V = 0$

E. $E = V$ **regardless of Q**

Scalar sum of potentials = 0

Vector sum of E-fields ≠ 0, and V changes as we go left to right in x

Get field from potential

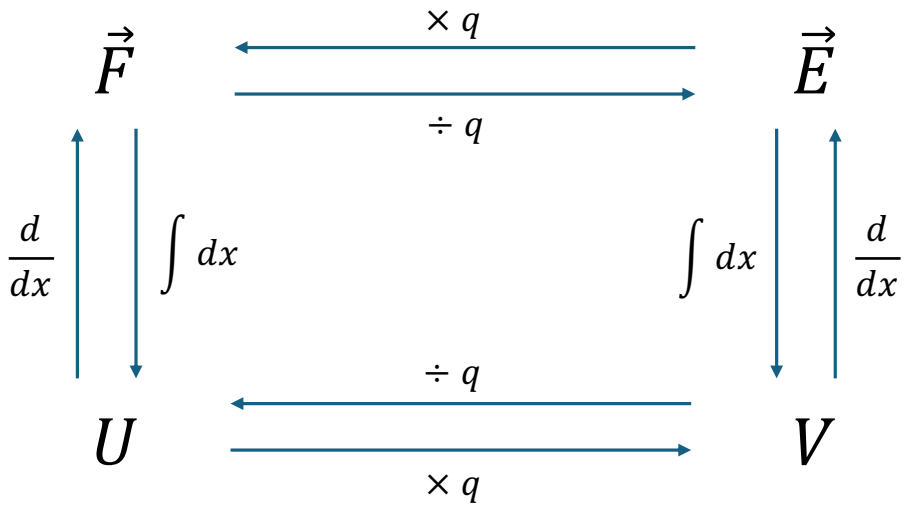
- It can be easier to calculate the potential of a charge distribution because you are just adding scalar values.
- Then, take a gradient to get the field.

- Example: ring of uniform charge potential

Potential from a distribution of charges

- Option 2: Integrate the field
  - First find the field, and then integrate to get the potential
  - This will be useful in situations where we have previously calculated the field or when we can easily find it through Gauss's Law

- Example: plane of charge


$\vec{F}$
$\times q$
$\div q$
$\vec{E}$
$\frac{d}{dx}$
$\int dx$
$\int dx$
$\frac{d}{dx}$
$\div q$
$\times q$
U
V