

Phys 102 – Lecture 5

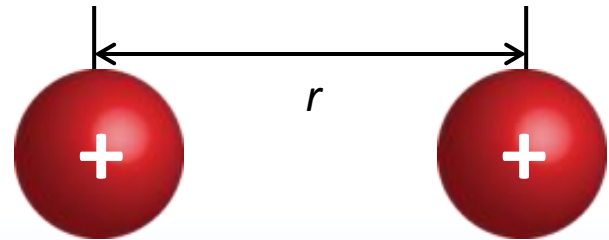
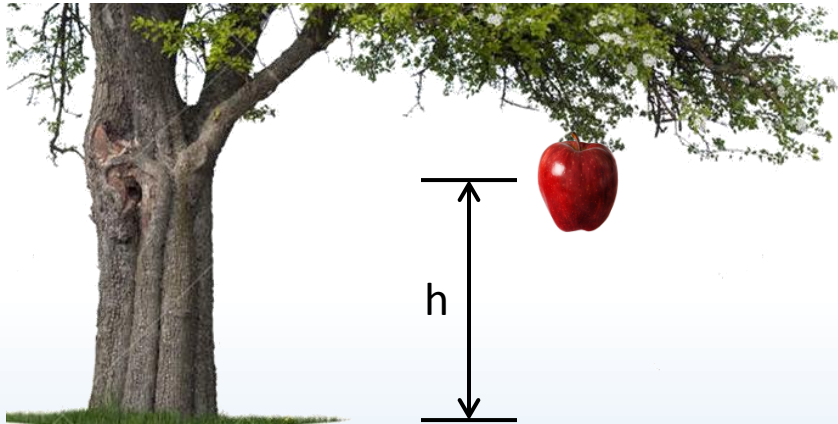
Electric potential

Today we will...

- Learn about the electric potential
- Use the principle of superposition
Ex: point charges
- Represent electric potential with equipotential lines
Relation with electric field
- Apply these concepts
Ex: Electrocardiogram (ECG)

Recall last time

Gravitational potential energy \longleftrightarrow Electric potential energy



Height or altitude \longleftrightarrow Electric potential

The electric potential

The electric potential is defined at a *location* in space around a charge or set of charges

Electric potential at position P →

$$V \equiv \frac{U_E}{q}$$

← EPE of a charge q at position P
← Charge q

Units: $\text{J/C} \equiv \text{V}$ (“volts”)

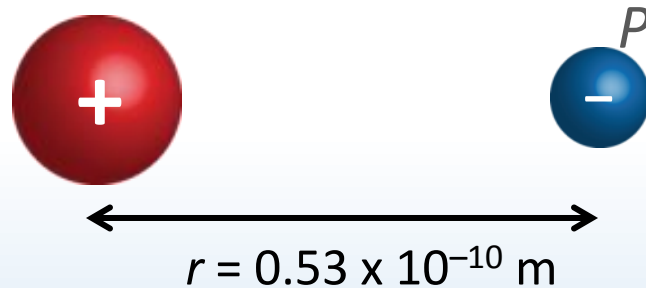
Electric potential is a scalar (a number) NOT a vector. Signs matter!

Electric potential is 9 V higher at + end than – end



Calculation: potential in H atom

What is the magnitude of the electric potential due to the proton at the *position* of the electron?

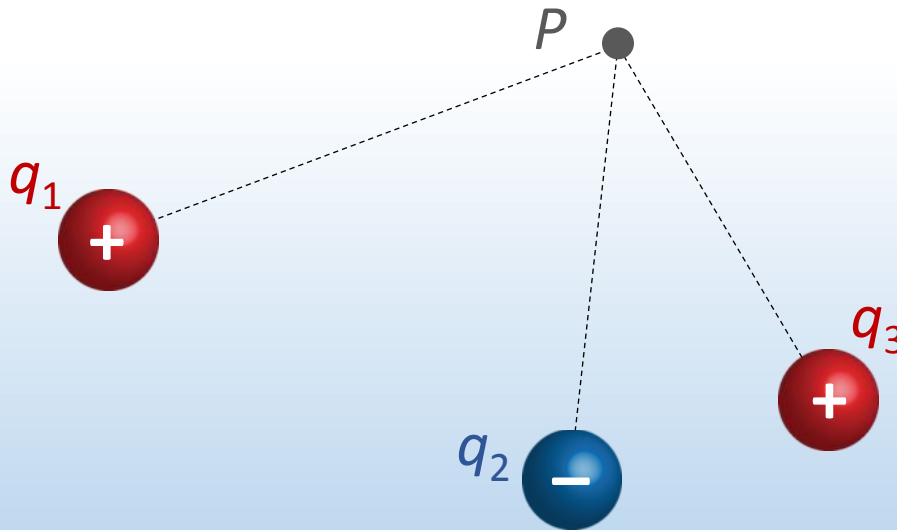


Superposition principle

Total potential due to several charges = sum of individual potentials

$$V_{tot} = \sum V$$

Ex: what is the electric potential at point P due to q_1 , q_2 , and q_3 ?

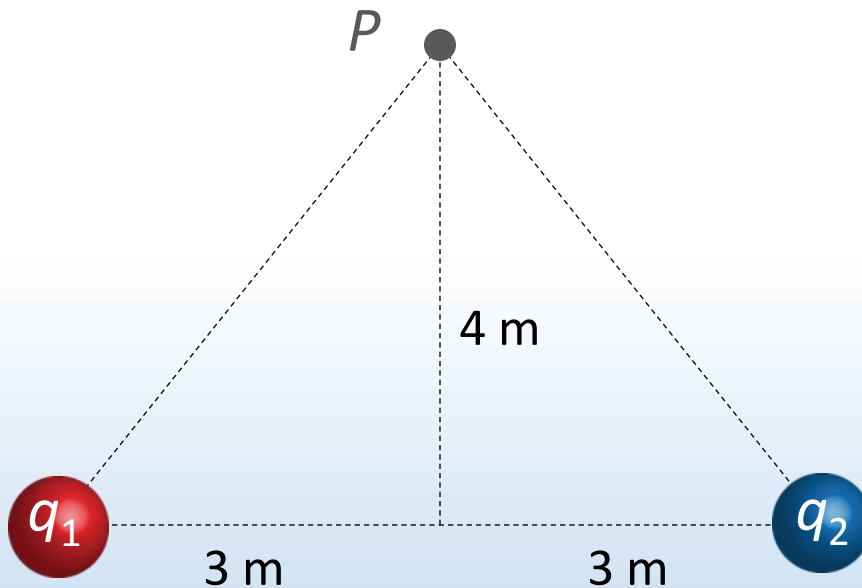


Simple addition, no vectors!
Watch for signs, though!

$$V_{tot} = V_1 + V_2 + V_3$$

Calculation: two charges

Calculate the electric potential at point P due to charges $q_1 = +7 \mu\text{C}$ and $q_2 = -3.5 \mu\text{C}$





ACT: Electric potential

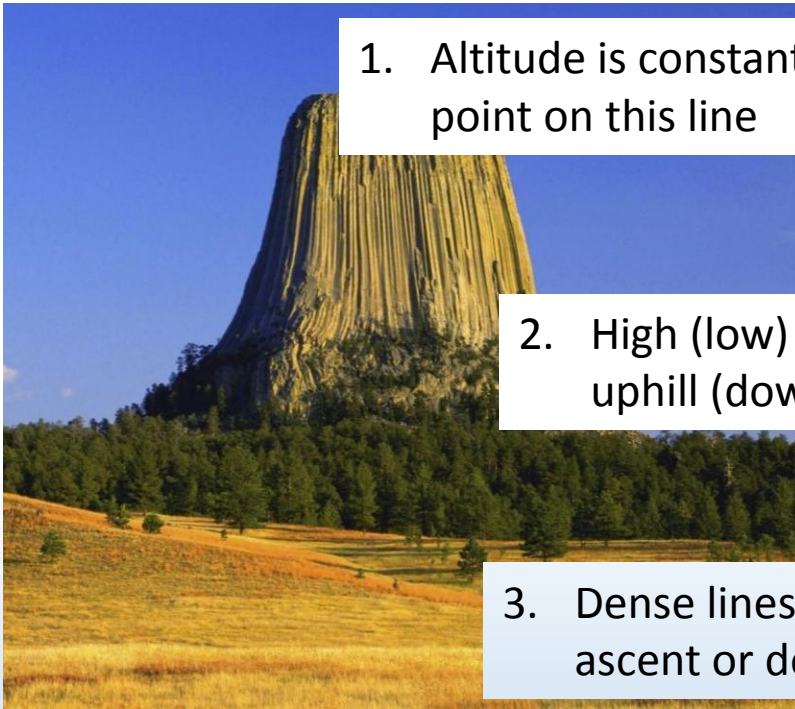
Two charges $+2Q$ and $-Q$ are placed on the x -axis. In which of the three regions I, II, or III on the x -axis can the electric potential be zero?



- A. I
- B. II
- C. III
- D. None of the above

Equipotential lines

Devils tower, WY

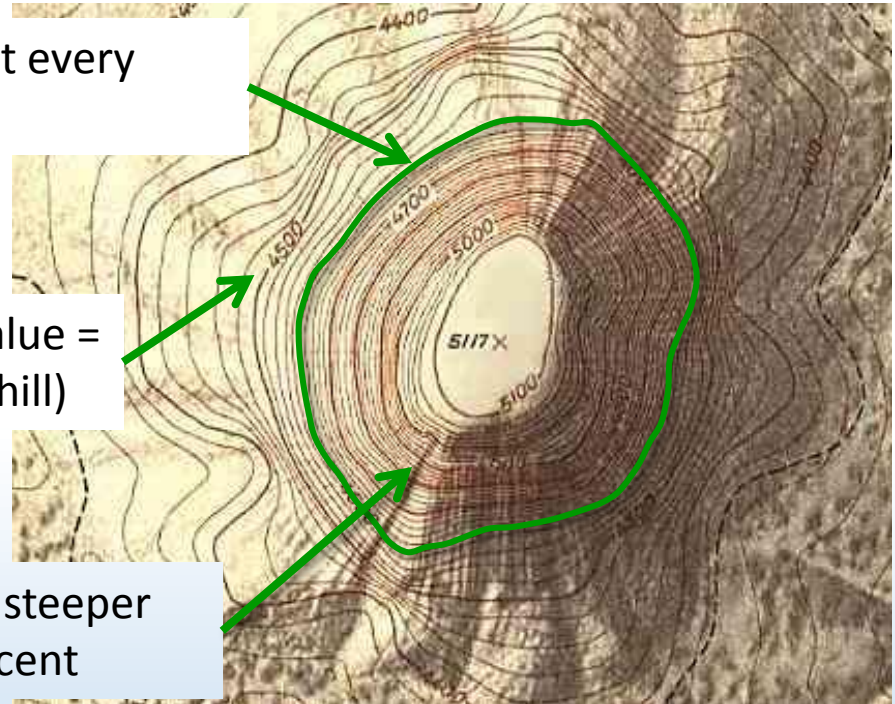


1. Altitude is constant at every point on this line

2. High (low) value = uphill (downhill)

3. Dense lines = steeper ascent or descent

Topographical map



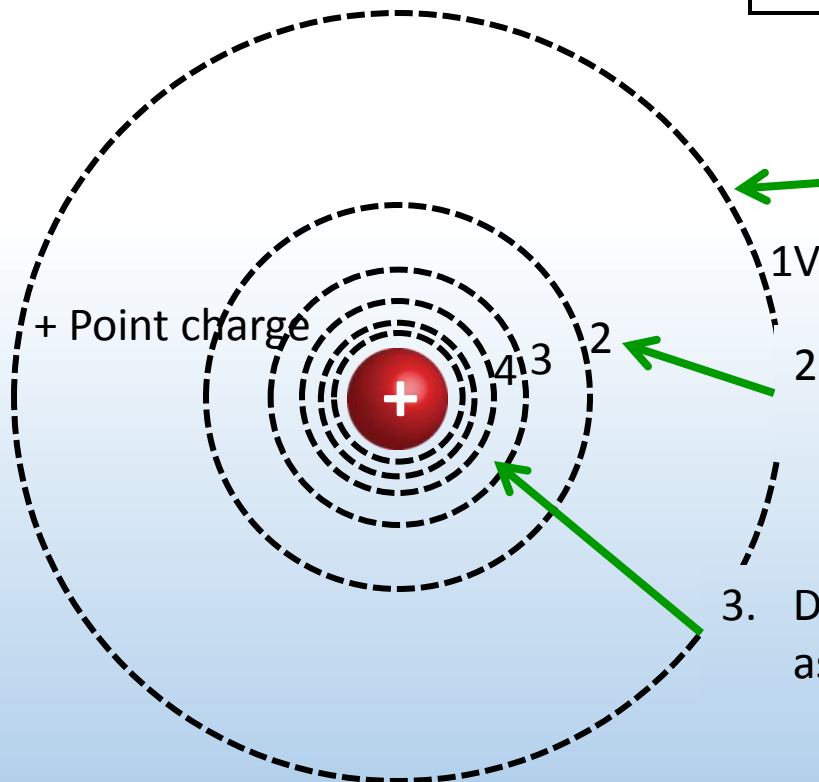
Gravitational potential energy \longleftrightarrow Electric potential energy

Height or altitude \longleftrightarrow Electric potential

Electric potential for a charge

Equipotential lines represent electric potential in space graphically

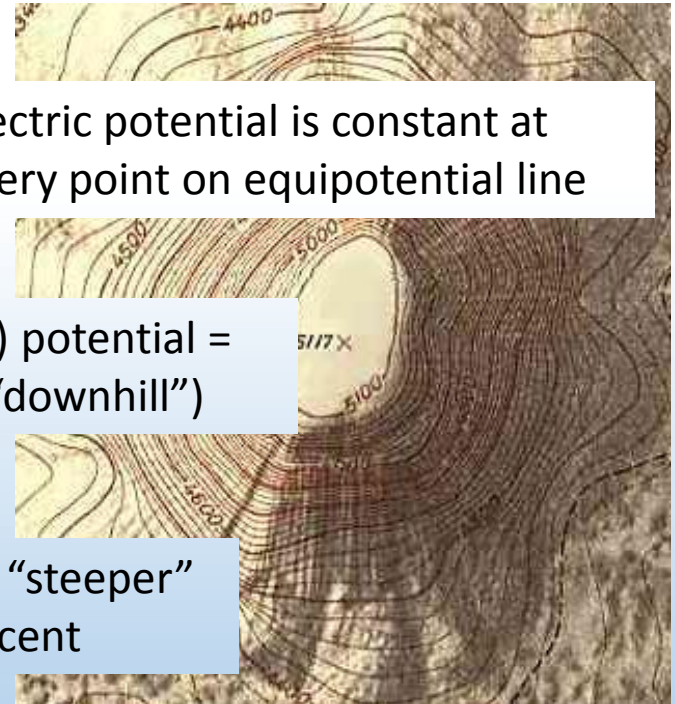
$$V = \frac{kq}{r}$$



1. Electric potential is constant at every point on equipotential line

2. High (low) potential = "uphill" ("downhill")

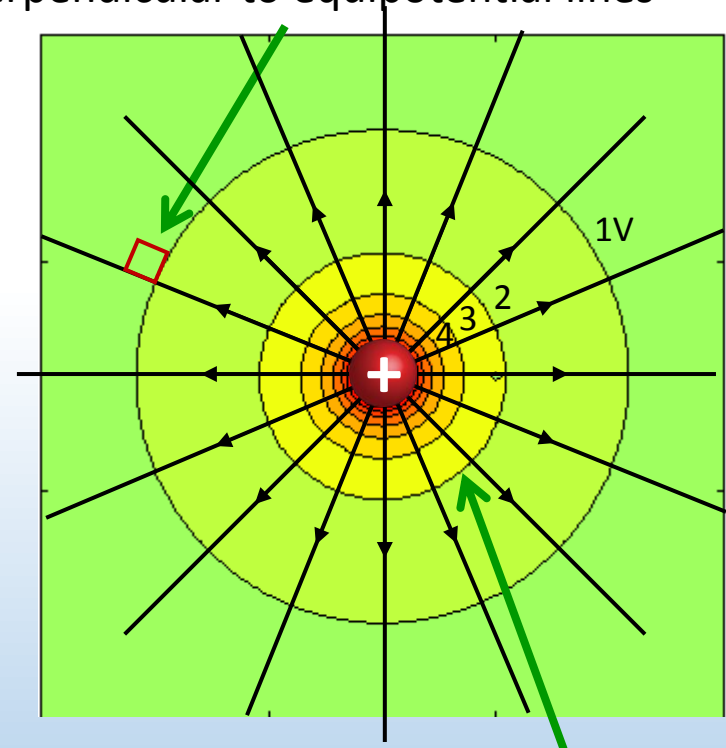
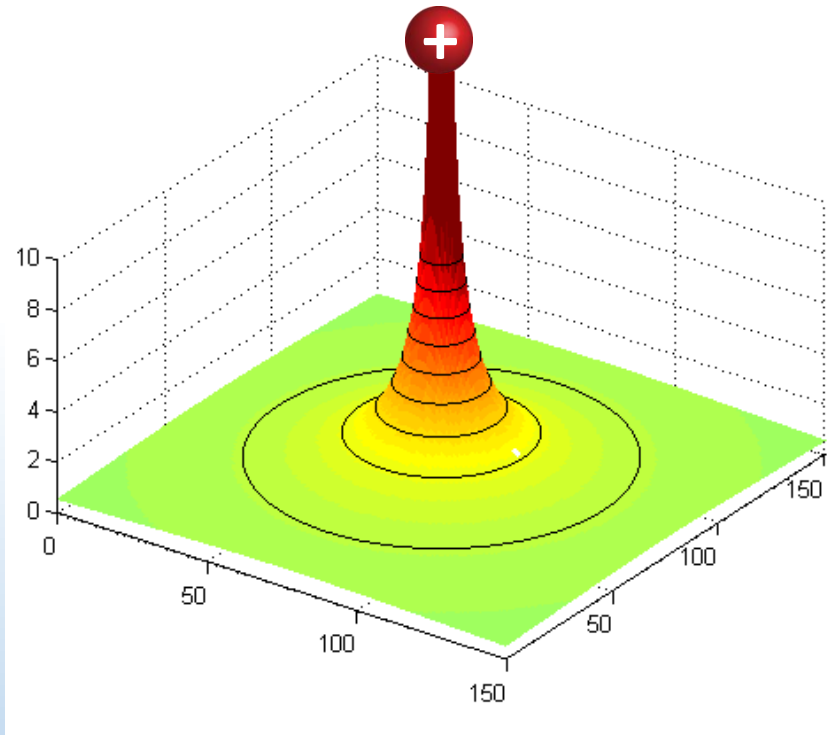
3. Dense lines = "steeper" ascent or descent



Equipotential & electric field lines

Equipotentials & electric field lines are geometrically related

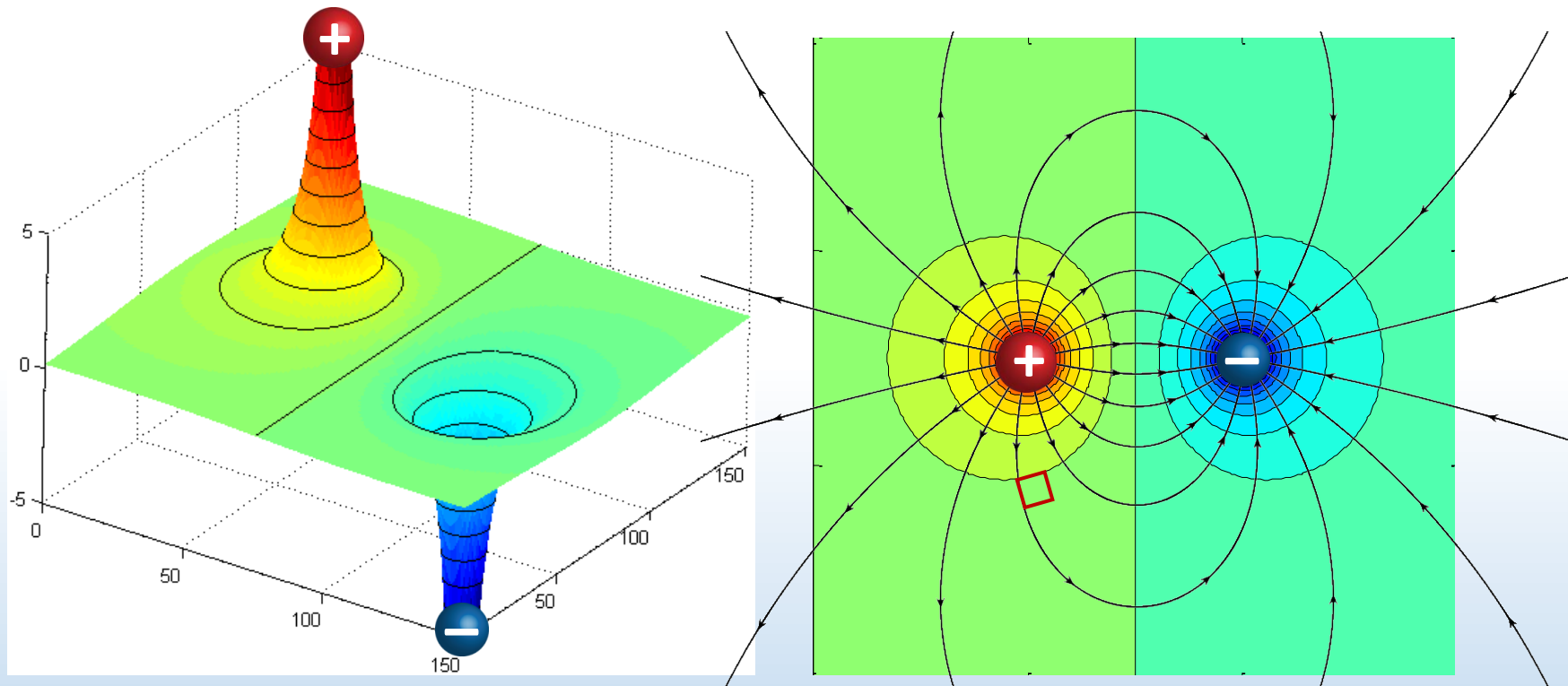
1. Electric field points “downhill”,
perpendicular to equipotential lines



3. Positive charge moves “downhill”
Negative charge moves “uphill”

2. Dense equipotential lines
= large E field

Electric potential for a dipole

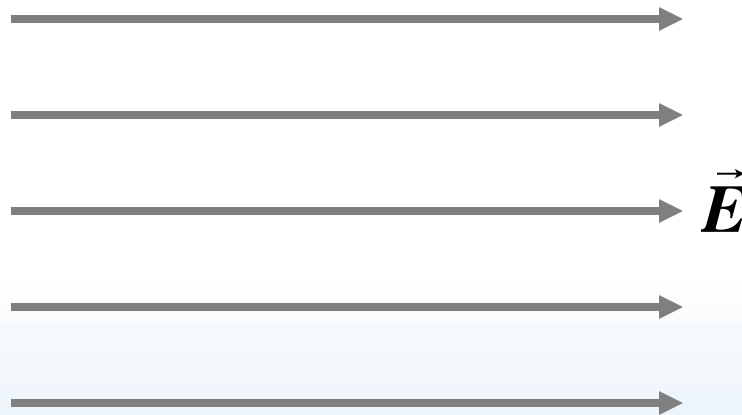


DEMO

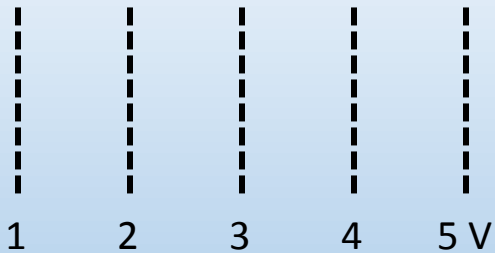


ACT: Uniform electric field

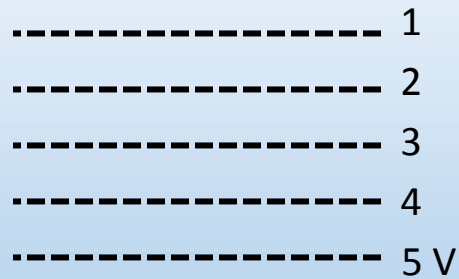
Which diagram best represents the equipotential lines corresponding to a uniform E field pointing to the right?



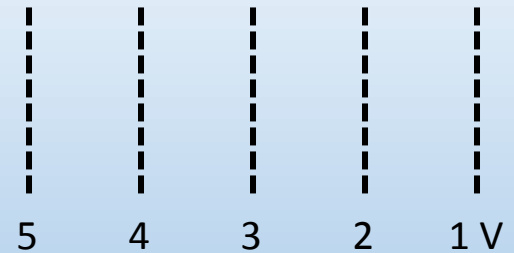
A.



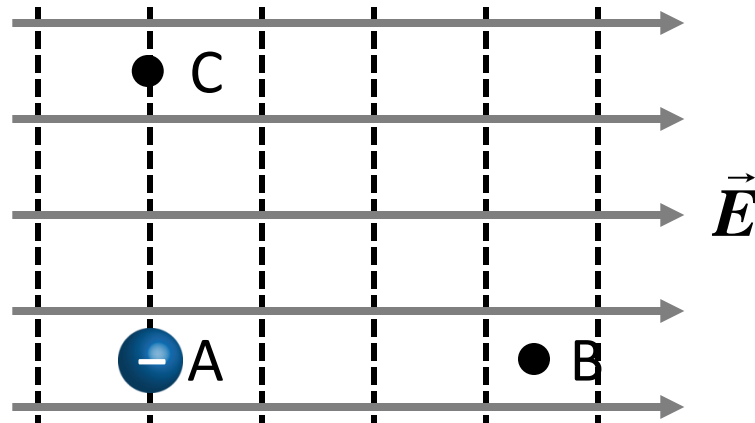
B.



C.



Lect. 4 Checkpoint 1.2 (Revisited)



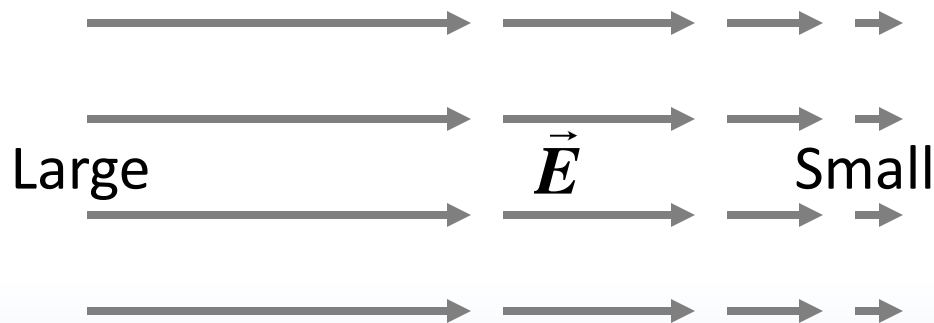
When a negative charge is moved from A to C, it moves along an equipotential line

- A. positive work
- B. zero work
- C. negative work

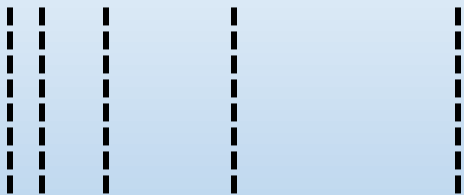


ACT: Electric field gradient

Now consider an E field that decreases going to the right. Which diagram best represents the equipotential lines?



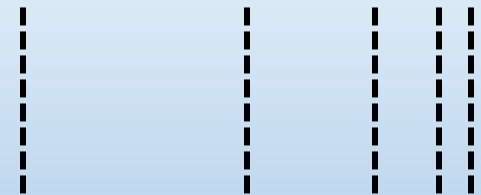
A.



B.



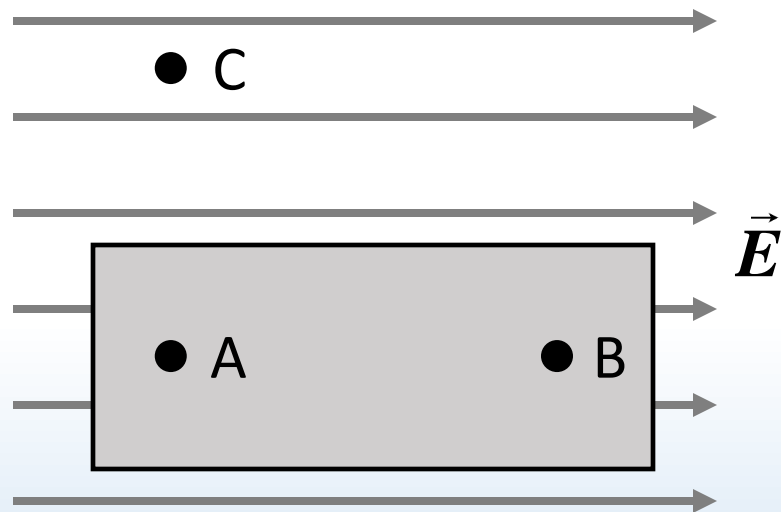
C.





ACT: CheckPoint 2.1

Points A and B lie in an ideal conductor inside a uniform E field

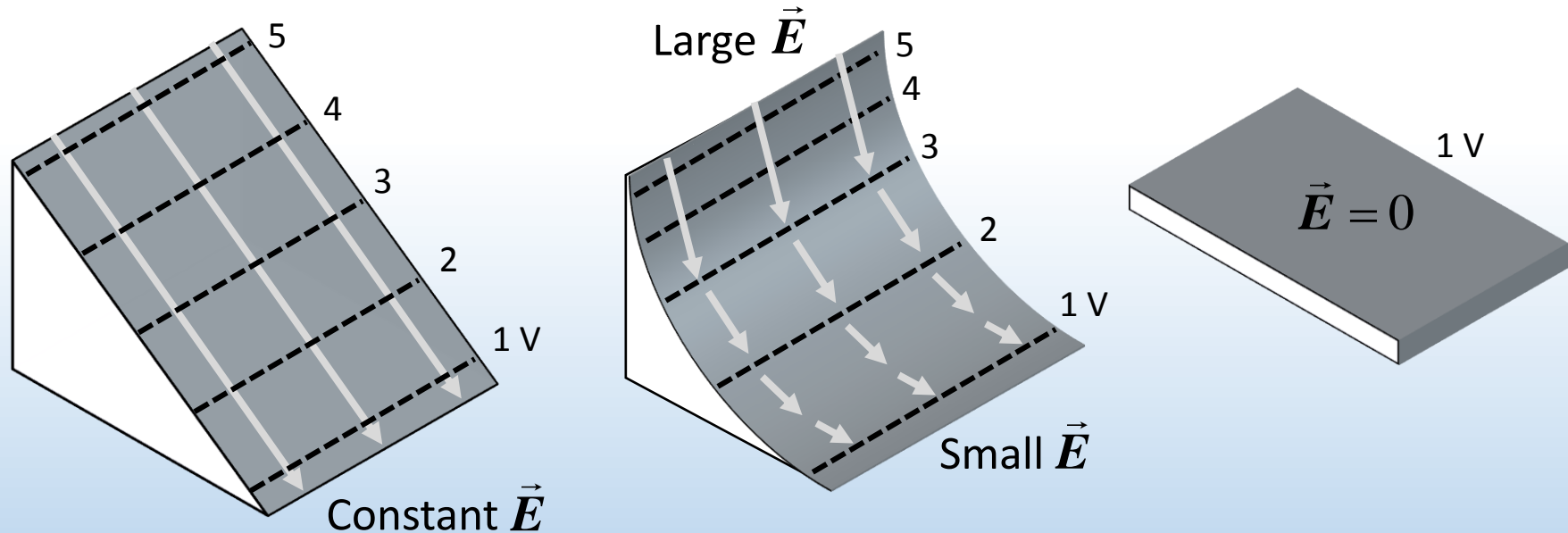


The electric potential at point A is _____ at point B

- A. Greater than
- B. Equal to
- C. Less than

Electric potential difference

Note that the electric field and force depend on electric potential difference ΔV , NOT on electric potential V itself

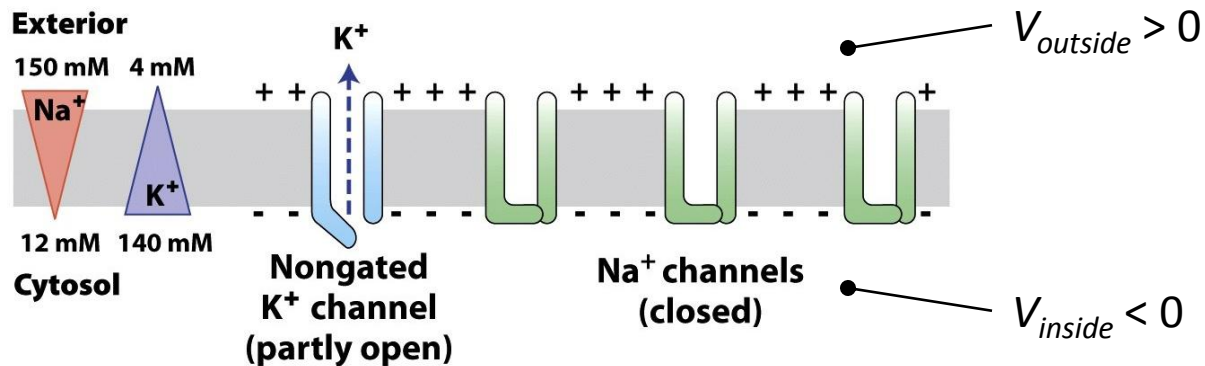


This will be important starting next lecture with circuits

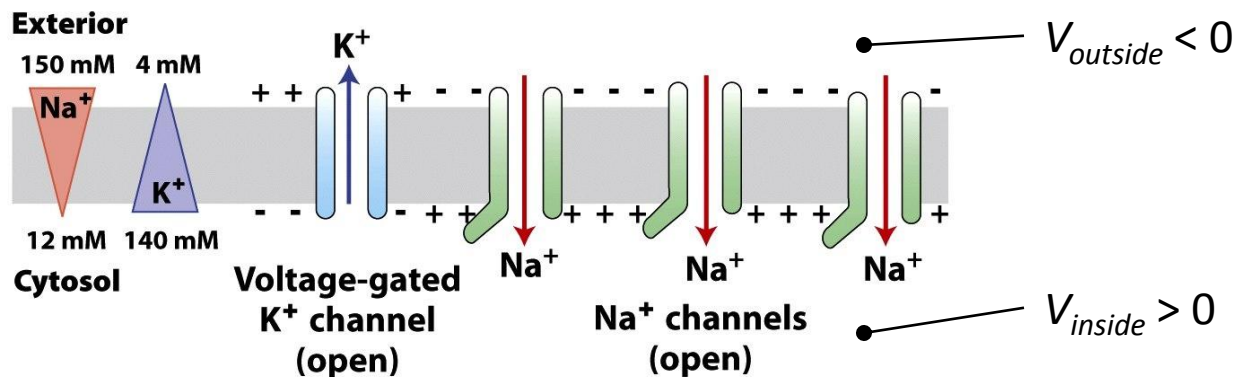
Electric potential in biology

Ion channels in cell membrane create a charge imbalance
Cells have an electric potential difference across membrane

Cells at rest are *polarized*

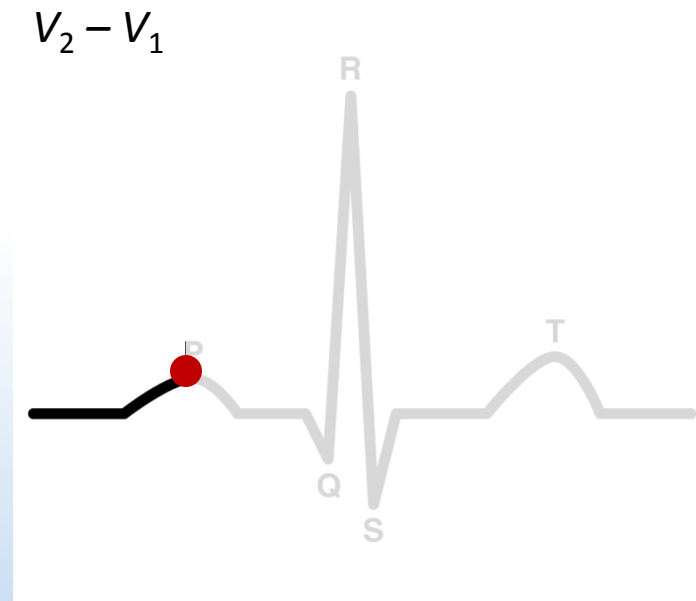
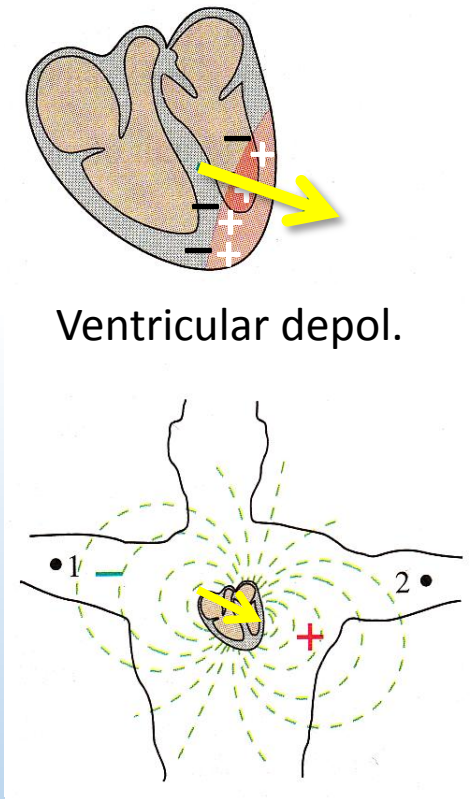


Some cell types (ex: neurons and muscle cells) *depolarize* when they fire



Electrocardiogram (ECG)

ECG detects electric potential difference from depolarization and polarization of cardiac tissue



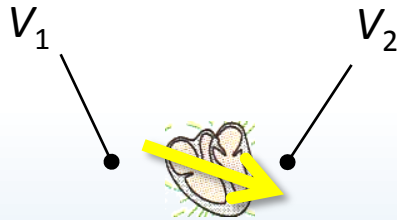
The heart behaves as time-varying electric dipole



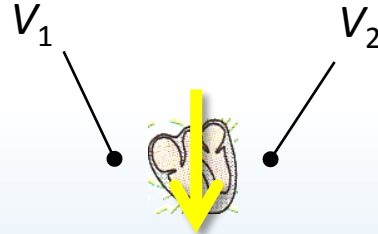
ACT: Electrocardiogram

At a certain time during an ECG you measure a negative electric potential difference $V_2 - V_1$. Which diagram of the cardiac dipole could be correct?

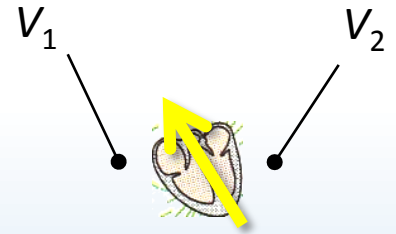
A.



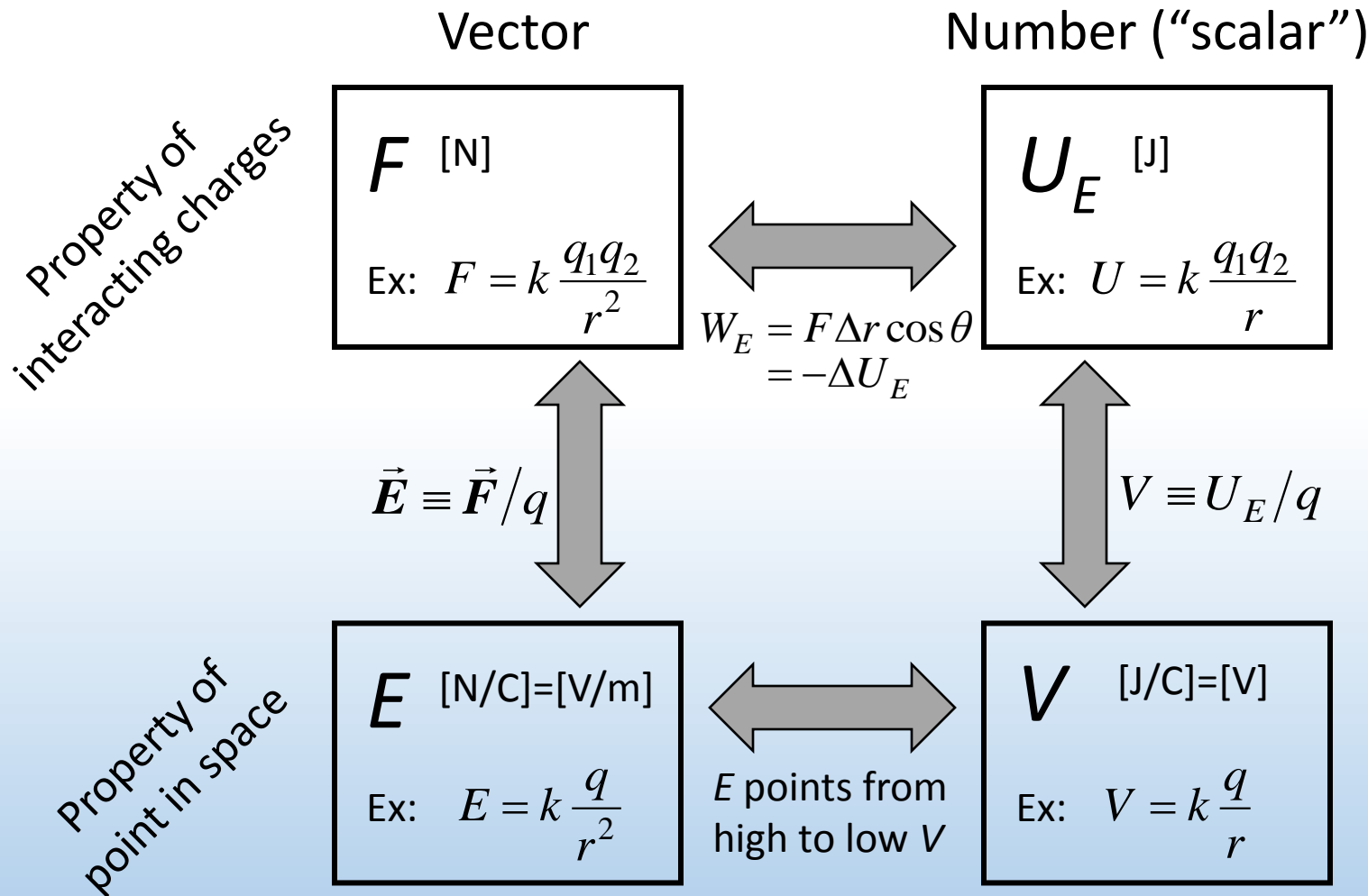
B.



C.



Relationship between F , E , U_E , V



Summary of today's lecture

- Electric potential

Superposition & point charges $V_{tot} = \sum \frac{kq}{r}$

- Equipotential lines

Relationship with electric field

Ex: Uniform field, non-uniform field, conductor, ECG