Physics 122 – Class #19 – (3/24/15)

- Announcements
- Exam Review
- Connections
  - Blitz summary of Chapter 28
  - Blitz summary of Chapter 29
  - Where does potential really come from?
- Capacitance
  - Parallel Plates
  - Energy in a capacitor
  - Of circuits – "Equivalent capacitance"
  - Of cylinders

Exam Grades

- 13 A's
- 13 B's
- 14 C's
- 9 D's
- 19 F's

- Mean 73
- Median 77
- Max 100
- Min 10

Midterm Grades

- 7 A's
- 17 B's
- 20 C's
- 12 D's
- 19 F's

- Details on Canvas.
- Clickers not included yet
- “A” on exams, “C” on HW, – “B”
- “D” on exams, “A” on HW, – “C”

Midterm Grades – What do I do?

- Numerical grade below 55% … drop course (Deadline 4/1) – 7 people
- Do old (MP) homeworks for 50% credit or more.
- Rework exam.
- Read book!
- Find more hours!
- Talk to advisor
- See tutors (OSS)
- See tutors (Physics grad students)

PHYSICS DROP-IN (HELP) SESSIONS WORKMAN 110

Monday:	**10:00am-12:00pm**	**Dana Baylis**
	12:00pm-2:00pm	**Gareth (Indy) Jones**
Tuesday:	9:00am-11:00am	Virginie Montes
	11:00am-12:00pm	Tina Gueth
Wednesday:	10:00am-11:00pm	Jose Martinez
	11:00am-12:00pm	James Price
	1:00pm-2:00pm	Jose Martinez
	2:00pm-3:00pm	Heather Bloemhard
Thursday:	11:00am-12:00pm	Tina Gueth
	1:00pm-2:00pm	Brandon Gray
	4:00pm-6:00pm	**Ryen Lapham**
Friday:	**12:00am-1:00pm**	**Brandon Gray**

Physics 122 – Class #19 –

- Homeworks due next Tuesday
- Reworked exams due next Tuesday (1/3 points back)
- Problems 4, 5, 10 in recitation

Reading Assignments

This week – Chapter 29 – Relation between electric potential and electric field. Combining capacitors.

Next week – Chapter 30 – Currents. Read all of it (it's less mathematical than most), but you may skip pages 873-874.

Lab next week is on series/parallel and RC circuits (Ch. 31).

Chapter 28 – Summary

- 28.1 Potential energy is calculated from work just like in Physics I.
- For constant field $U = -\vec{F} \cdot \Delta \vec{r}$

$$U_{grav} = m g y \qquad U_{elec} = q E s$$

- 28.2 For a varying field

$$U(x) = -\int_0^x F(x')\,dx'$$

- For a point mass/charge,

$$U_{grav} = -G\frac{m_1 m_2}{r} \qquad U_{elec} = k\frac{q_1 q_2}{r}$$

Chapter 28 – Summary

- 28.3 Dipoles … nevermind
- 28.4 Electric potential (Volts) is Potential energy (Joules) over q.

$$V = U/q$$

- 28.5 In a parallel-plate capacitor

$$U_{elec} = qEs \rightarrow V = U/q = Es$$

- 28.6 For a point charge

$$V = U_{elec}/q_2 = k\frac{q_1 q_2}{r q_2} = k\frac{q_1}{r}$$

- 28.7 Got more charges? Sum potentials!

Exam Review (all except 4, 5, 10)

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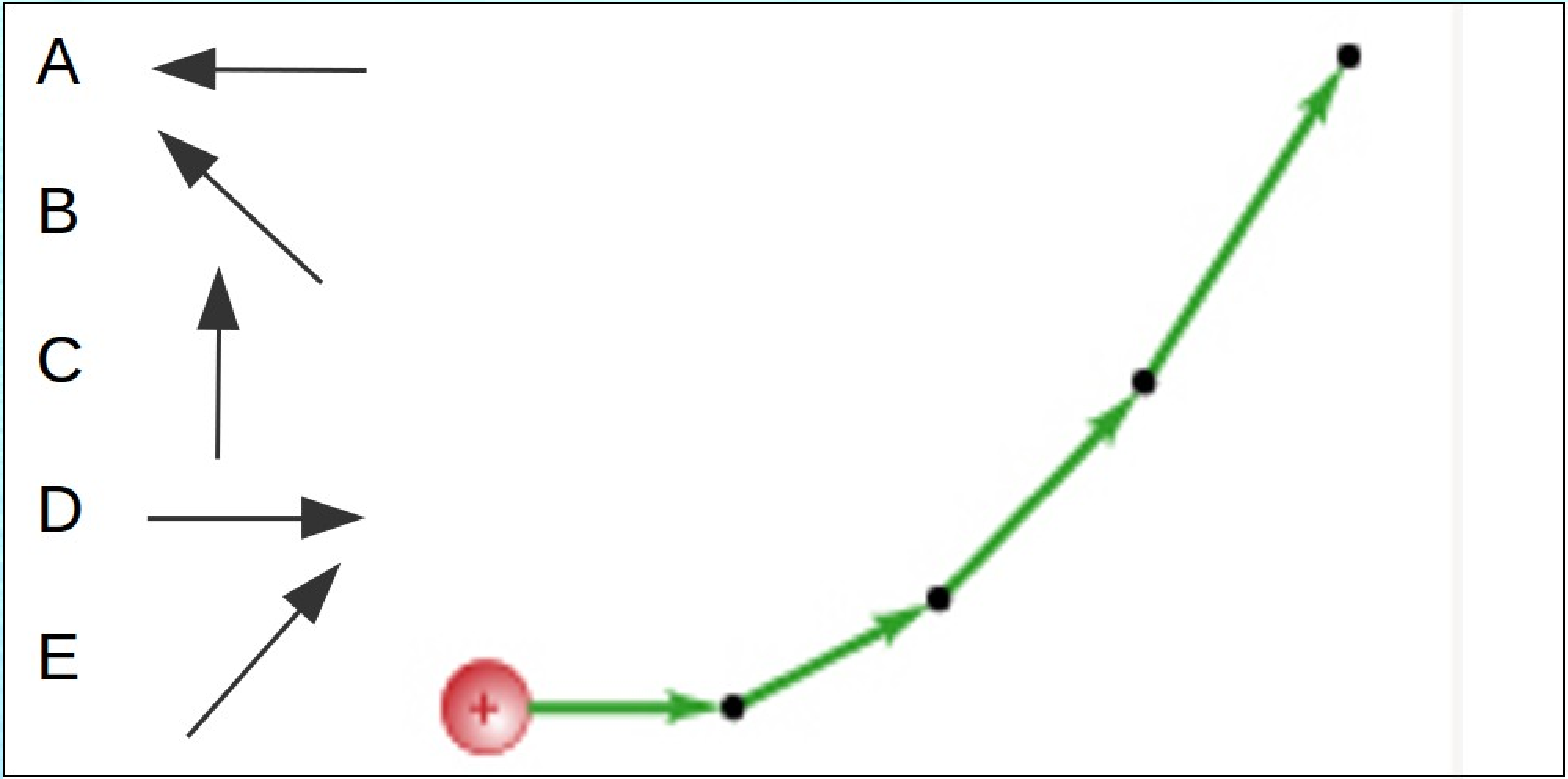
A
B
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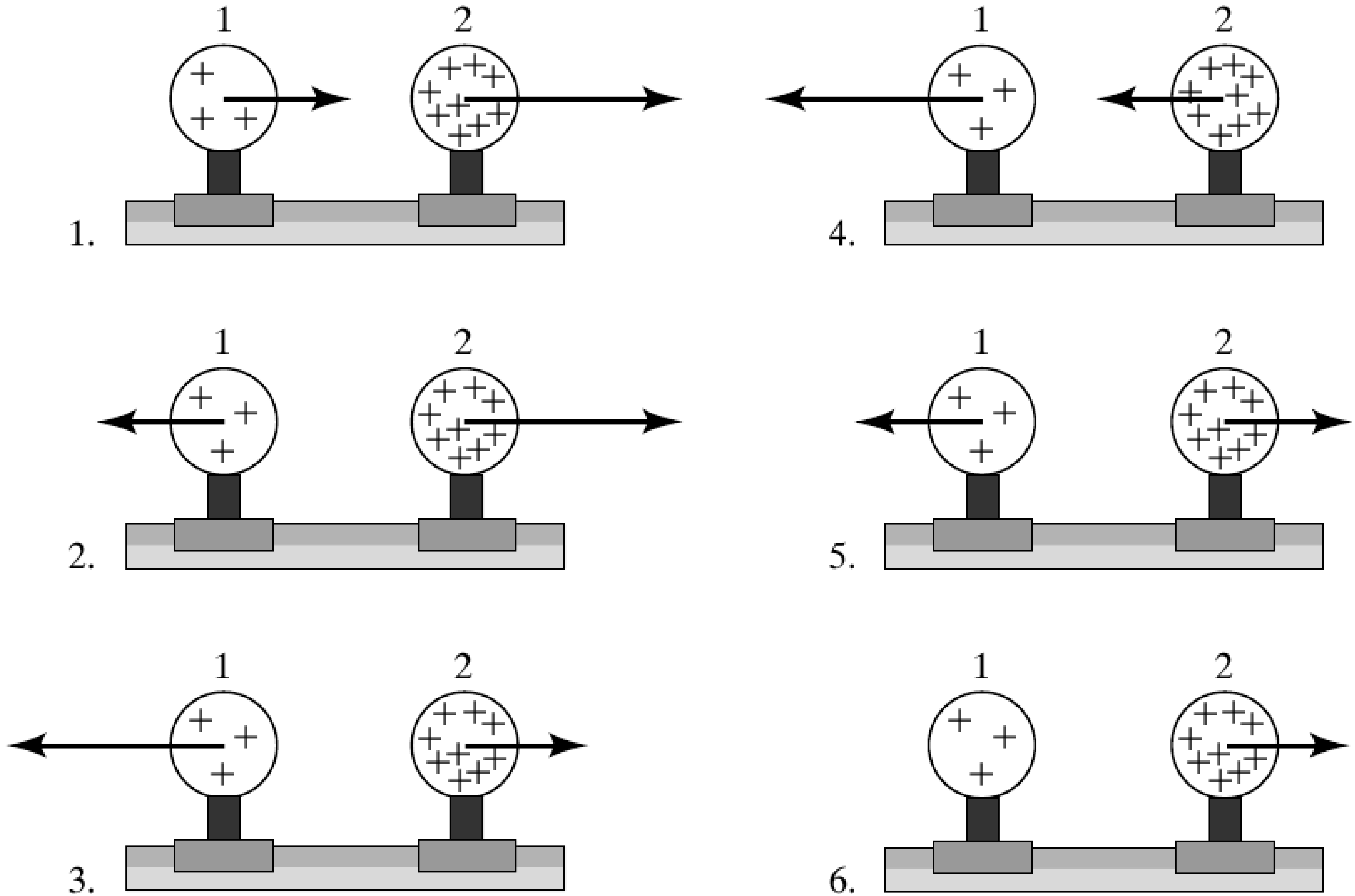
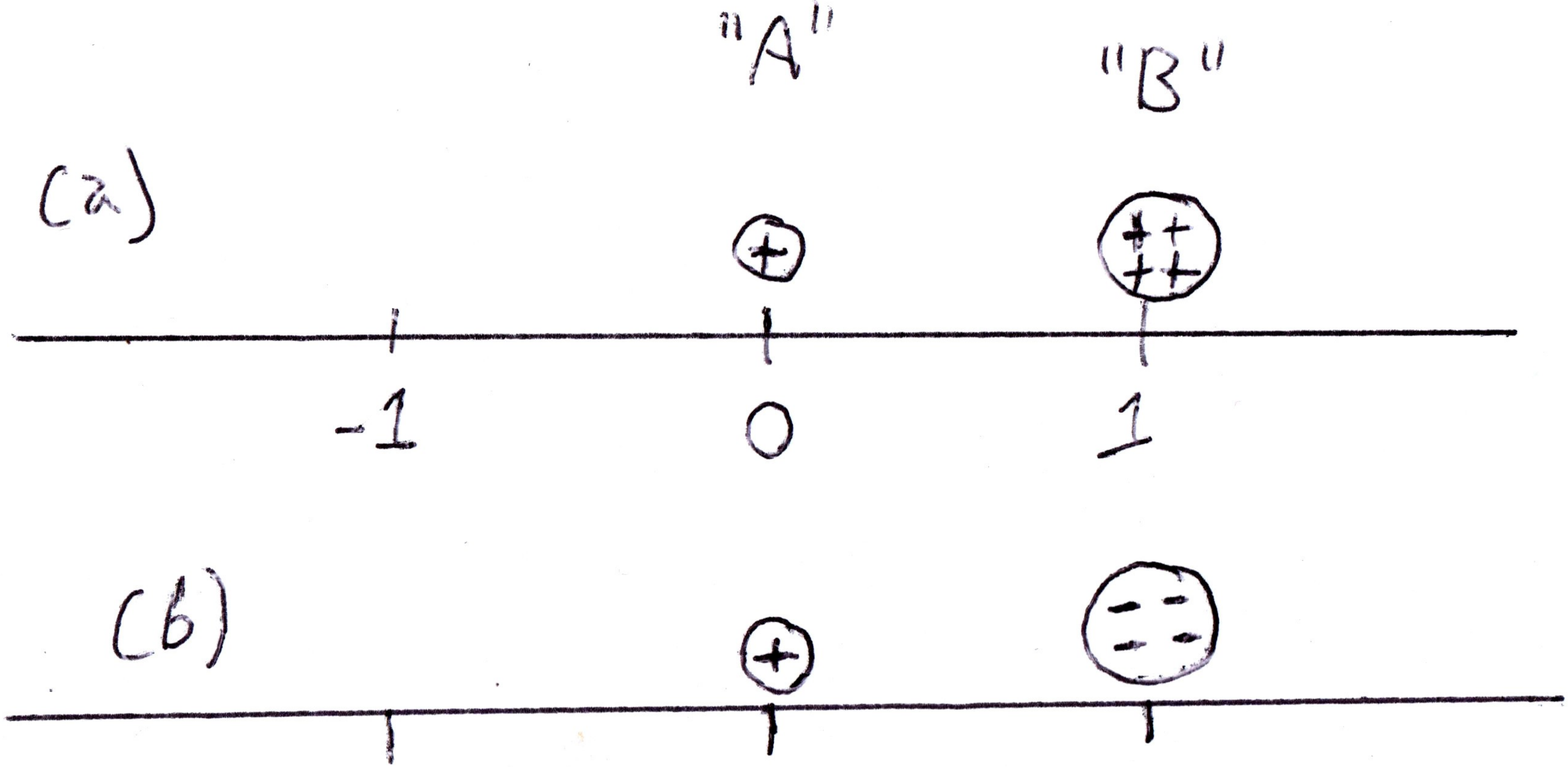
+



7. none of the above


"A"
"B"
(a)
-1
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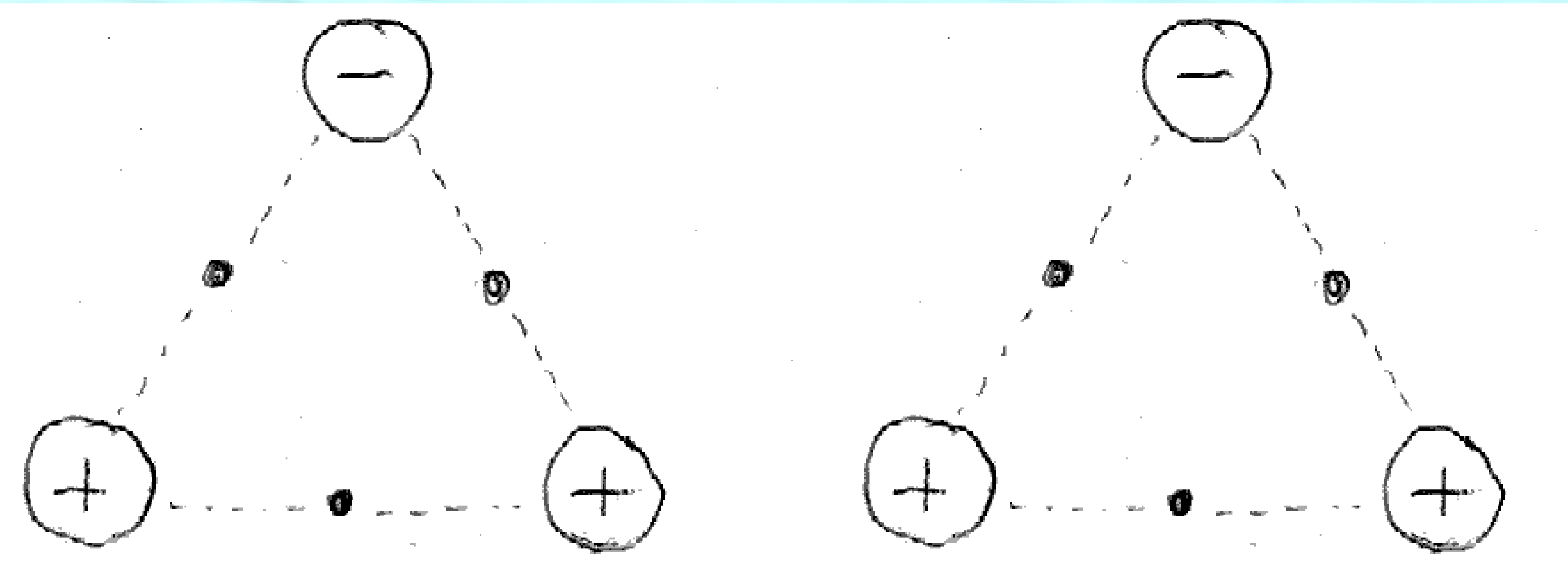
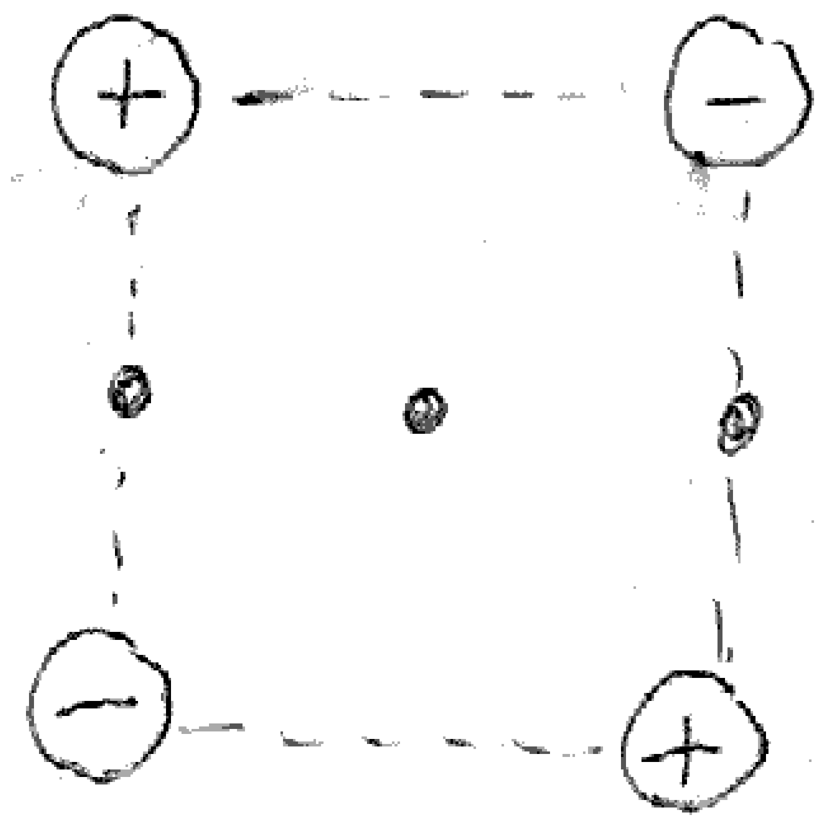
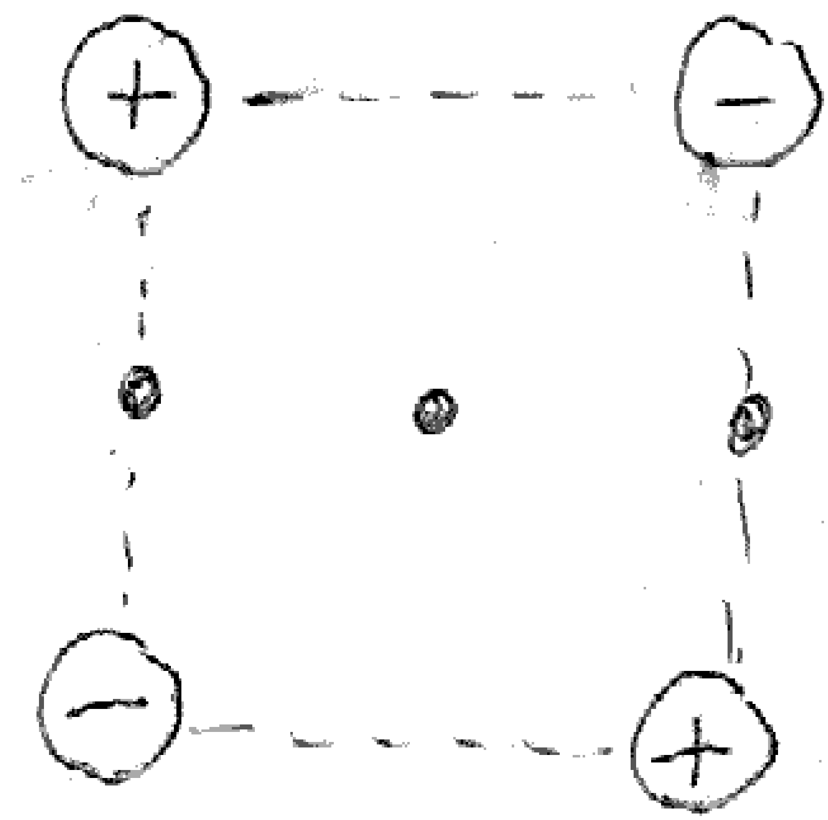
1
(b)







Chapter 29 – Summary

- 29.1 You can integrate E(x) to get V(x) get E(x) from dV/dx.
  This allows understanding the formula for a parallel plate capacitor.
- 29.2 You "manufacture" potential with a battery, or a Van de Graaf … or a power plant!
- 29.3 E is the "gradient" of potential AND Potentials add in series.
- 29.4 Every point in a conductor is at the same potential.

Chapter 29 – Summary

•29.5 Q=CV

Capacitances in Parallel Add.

You need a reciprocal formula for capacitances in series.

•29.6 Capacitors store energy and charge

•29.7 Dielectric materials let you store more energy and charge in the same space then using air or a vacuum.

Potential Energy to Power

If you let a charge move through a potential, it acquires kinetic energy. You can create a potential by supplying either kinetic energy or some non-electrical energy.

In our lives, we pay money for potential, either by paying for batteries (chemical energy) or by paying a power company and plugging in.

How does this potential get there?
In practice lots of chemical energy (coal, oil) is converted into electric potential … and we love it!

Electrical Units

Potential Energy = Charge x Potential (U = Q V)
Power = Energy/time = QV/t = (Q/t) V = I V

Charge – Coulombs
Charge/time – Coulombs/second = Current (Amperes)
Electric Field – Newtons/Coulomb or Volts/meter
Electric Potential – Joules/Coulomb (or Volts)
Power = Joules/second =
Coulomb/sec x Joules/Coulomb = I V

Electric Power Plants

"How Power Plants Work Fisk and Crawford"

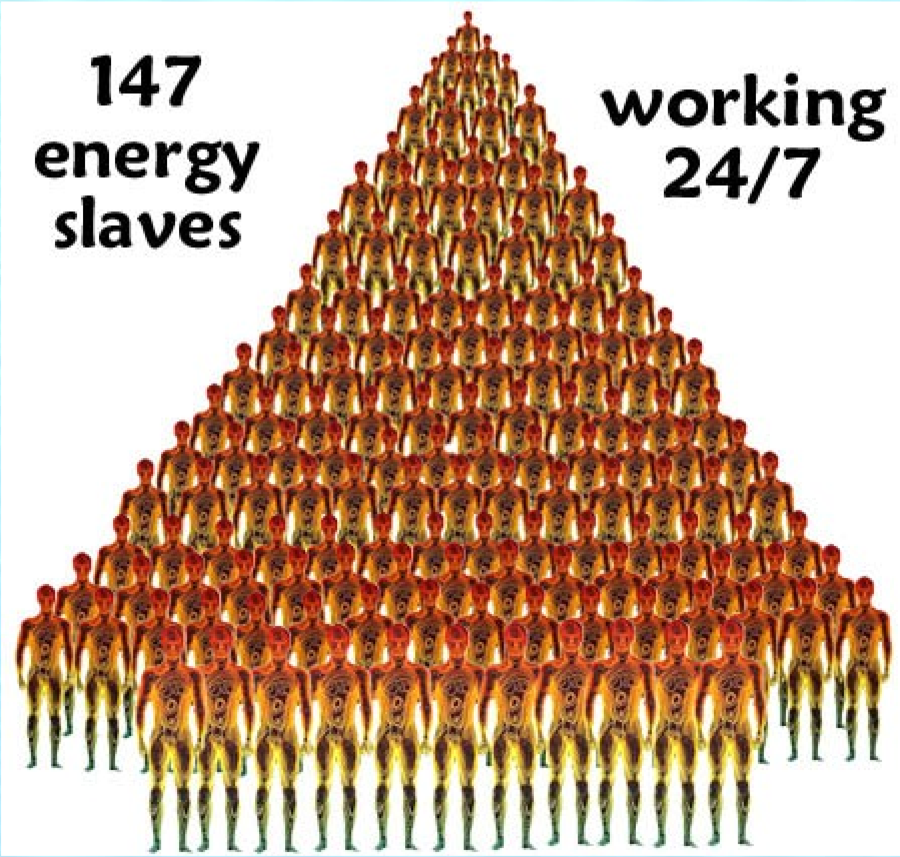
Tinyurl.com/fourcornerspowerplant
http://tinyurl.com/feedingacoalfiredplant

Chapter 33 – How electrical generators work

We burn fossil fuel to generate electricity

One gallon of gasoline is about 100 million joules = 40 kiloWatt Hours, is 600 people working as hard as they can for an hour.

Our wonderful lifestyle is Sustained by “energy slaves”



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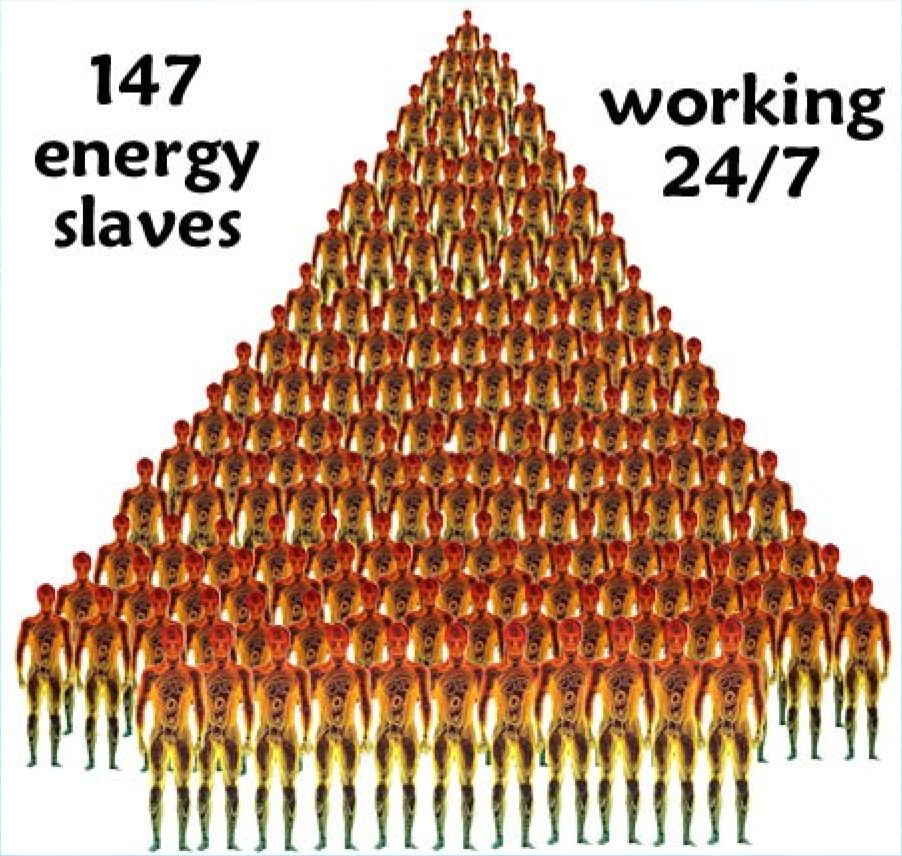


You are all Pharoahs.

Chapter 29

Big Idea: All electric fields represent stored energy. And capacitors are convenient containers for electric fields.

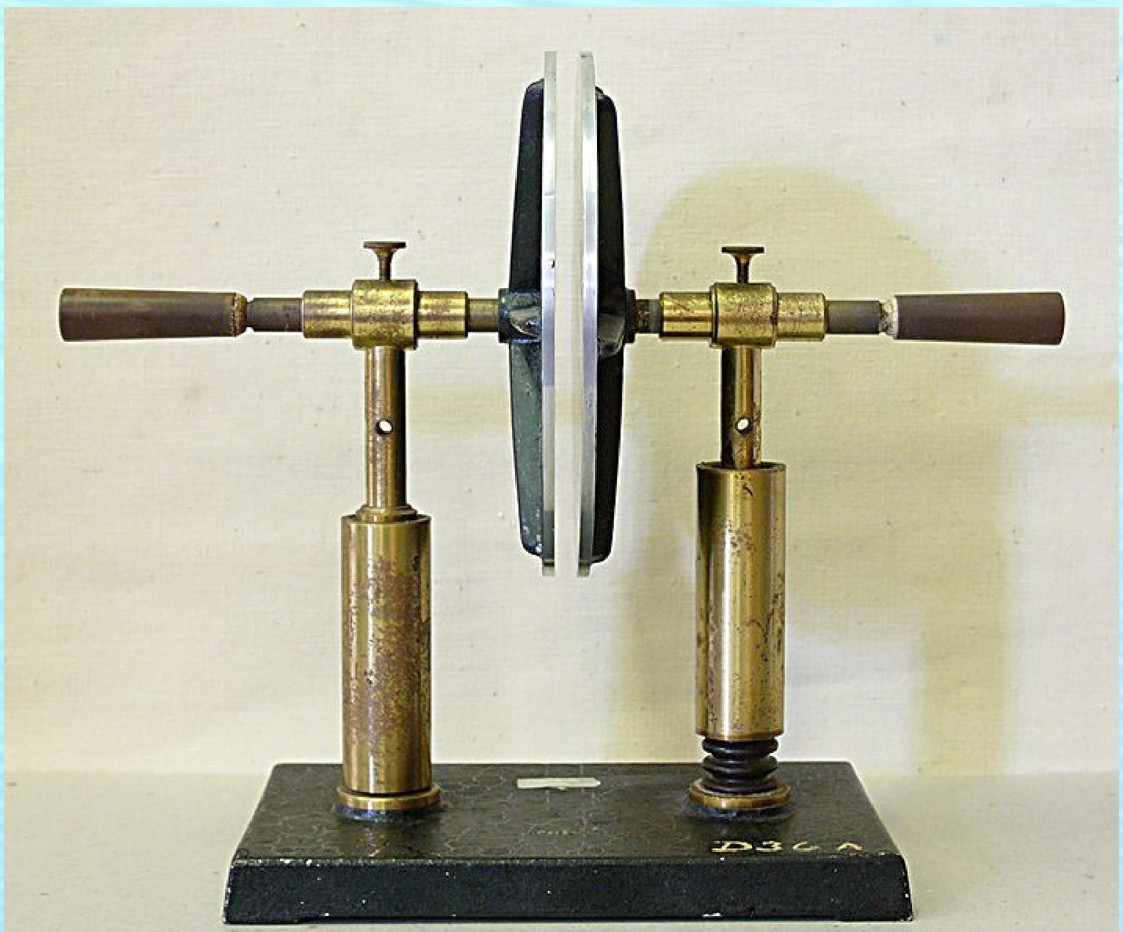
Definition: Capacitance relates Voltage to stored charge. Generally voltage is easier to measure than charge.

$$C = \frac{Q}{V} \qquad Q = C\,V$$

New SI Unit: “Farad”. [C]=[F][V]
(Coulomb=Farad x Volt)

It takes ever higher pressure to force more water into a full tank, and ever higher voltage to force more charge onto a charged capacitor.

$$Q=\frac{\epsilon_0}{d}\ A\,V \qquad\qquad M_{water}=\frac{1}{g}\ A\,P$$



A water tank gets deeper as you Increase pressure, but the plates Of a capacitor don't get further apart As you increase voltage.

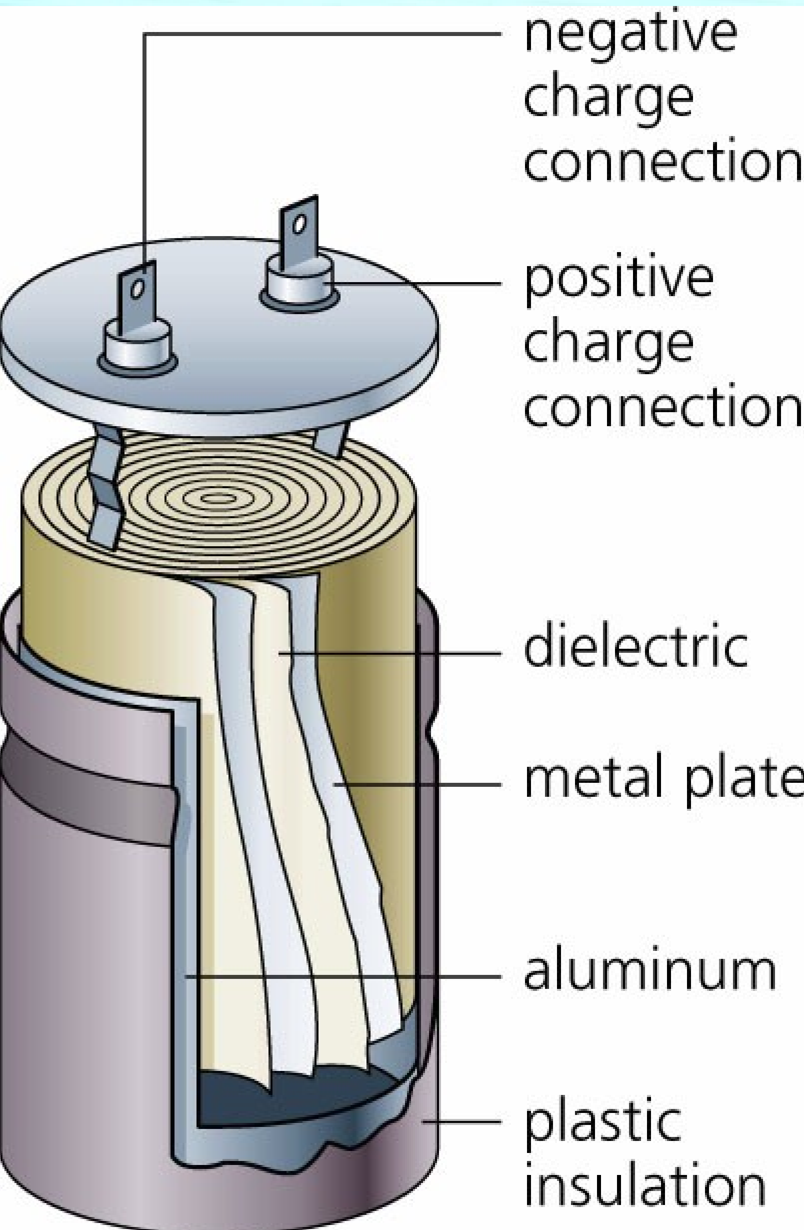
“Capacitance”, sounds like “Capacity”, and it is related. A large bottomed tank has a larger fluid capacity at given pressure than a small tank. “Voltage” is like “Pressure”

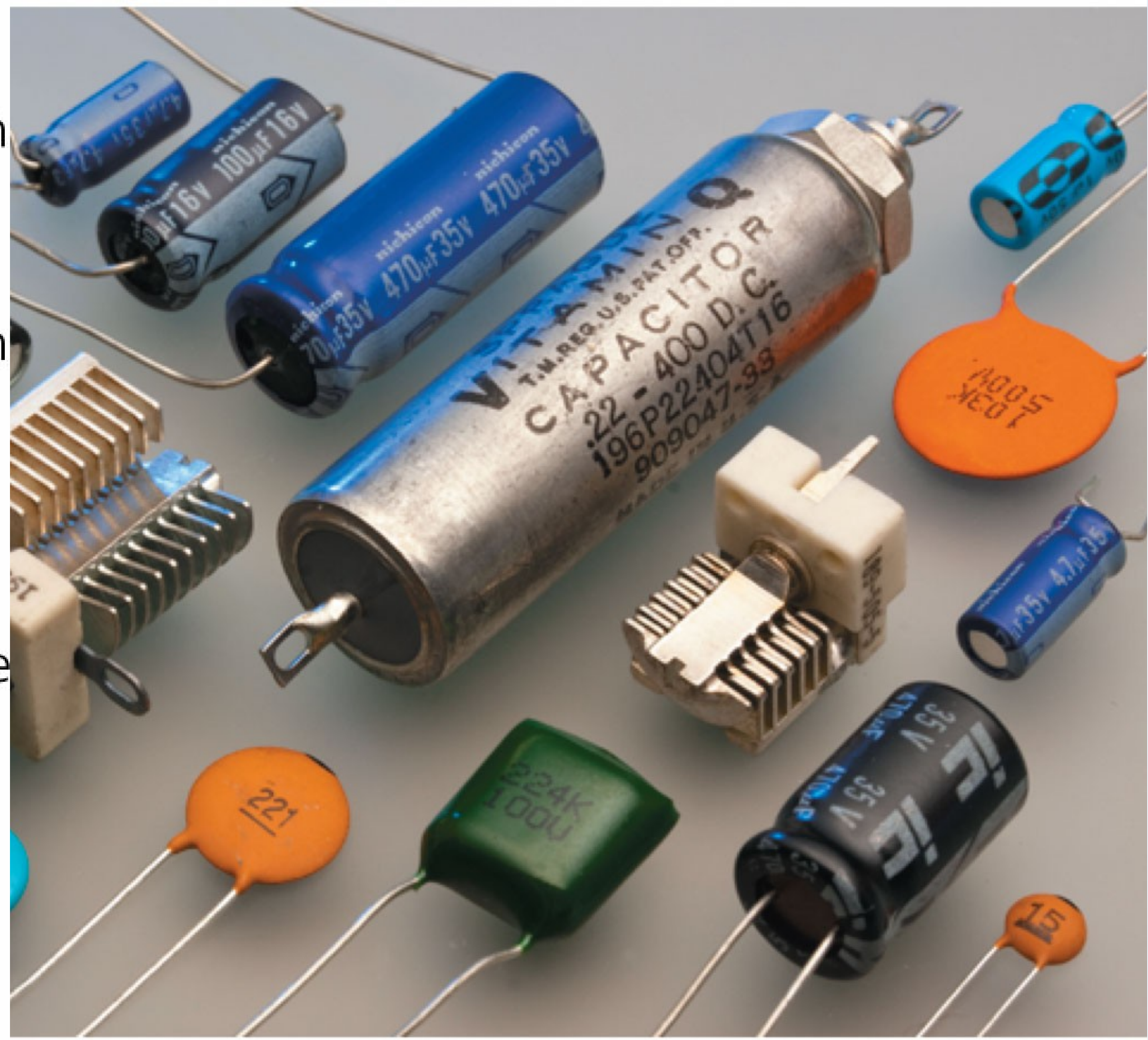
A large area capacitor has a larger charge capacity at given voltage than a small area capacitor.

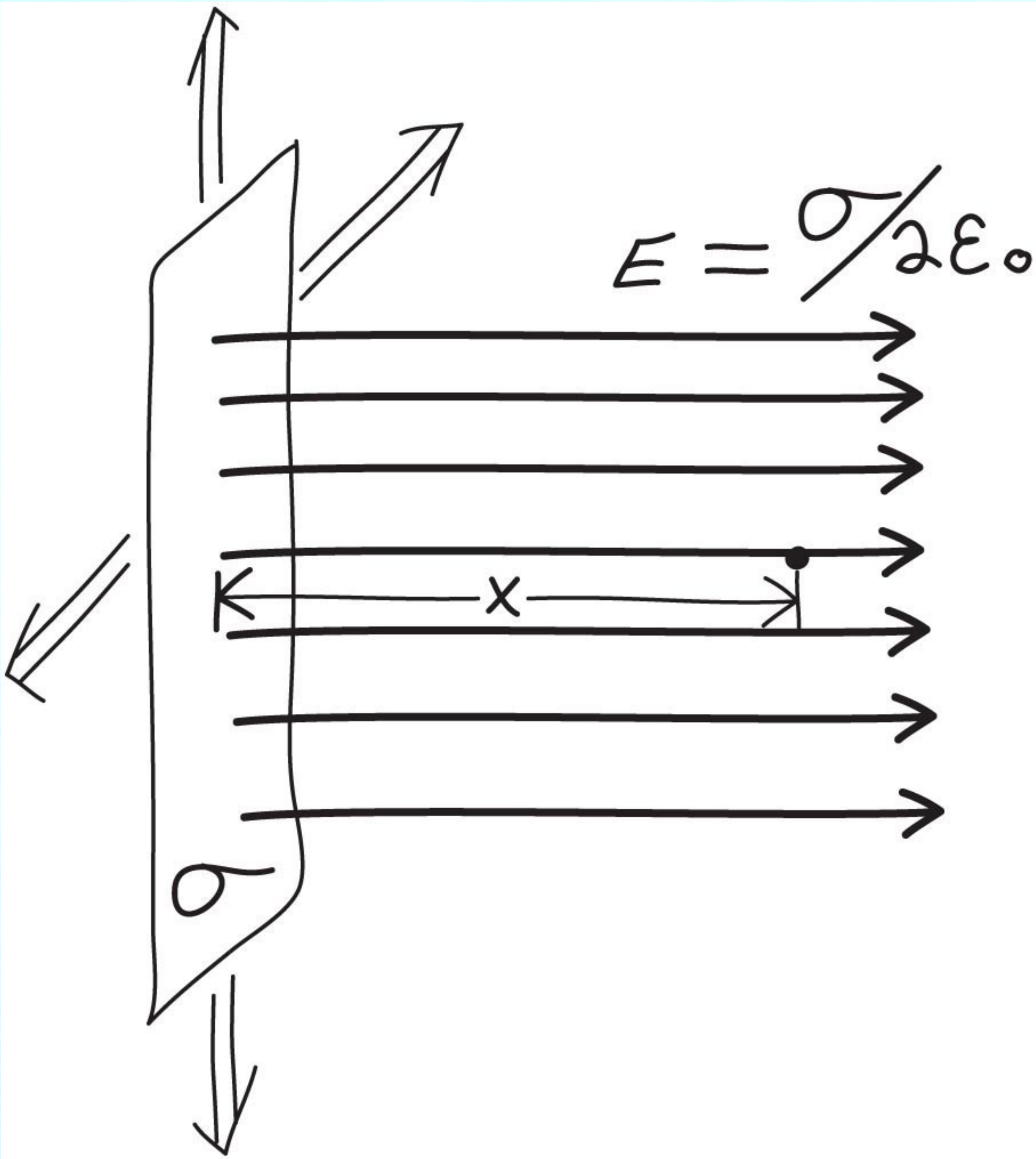
$$Q = \frac{\epsilon_0}{d} A V \qquad \text{Mass} = \frac{1}{g} A P$$

$$\epsilon_0 = 8.86 \times 10^{-12} F/m, \ (C/V\,m), \ (J/V^2)$$

What Commercial Capacitors Look like







E-Field of a "large" charged plate:

$$\vec{E} = \frac{\sigma}{2\epsilon_0}\hat{i}$$

$$\sigma = \frac{Q}{A}$$

$$V = -\int_0^x E \cdot dx'$$

E-Field of an infinite charged plate:

$$\vec{E} = \frac{\sigma}{2\epsilon_0}\hat{i} \qquad V = \frac{U}{q} = -\int_0^x E \cdot dx'$$

Electric Potential of an infinite plate:

[A] $V = \frac{\sigma^2}{4\epsilon_0}$

[B] $V = -\frac{\sigma^2}{4\epsilon_0}$

[C] $V = \frac{\sigma}{2\epsilon_0}x$

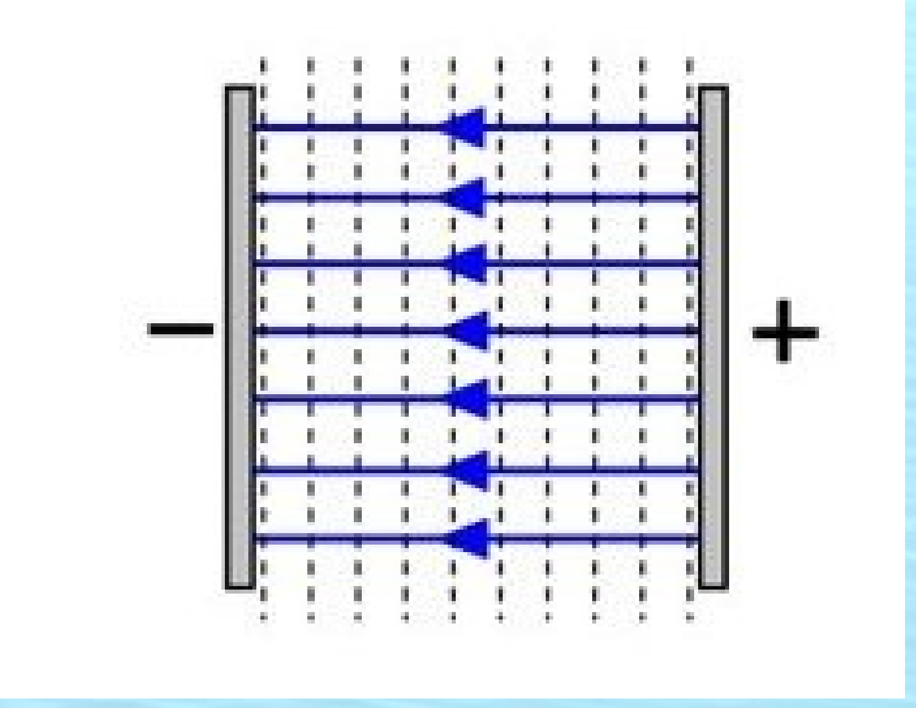
[D] $V = -\frac{\sigma}{2\epsilon_0}x$

Electric potential of TWO large plates
(Area “A” separation “d”) …
Electric field is doubled because two charged plates of opposite sign.

$$\vec{E} = \frac{-\sigma}{\epsilon_0} \hat{i}$$

$$V = -\vec{E} \cdot \Delta \vec{r} = E d$$

$$V = \frac{\sigma}{\epsilon_0} x = \frac{\sigma}{\epsilon_0} d$$



Deriving Parallel Plate Formula

$$[1]\ Q = C V$$

Definition of Capacitance

$$[2]\ V = \frac{\sigma}{\epsilon_0} d$$

Shown on last page

$$[3]\ \sigma = \frac{Q}{A}$$

Definition of surface charge density

$$[4]\ V = \frac{Q}{\epsilon_0 A} d$$

Plug 3 into 2

$$[5]\ Q = \frac{\epsilon_0 A}{d} V$$

Solve for Q

$$[6]\ C = \frac{\epsilon_0 A}{d}$$

How many capacitors are in your dorm room or house?

(A) None – I do not own a time machine or a DeLorean.

(B) About a dozen – Capacitors are energy storage and signal filtering devices used in power supplies for all electronics.

(C) Billions

How many capacitors are in your dorm room or house?

(A) None – I do not own a time machine or a Delorean.

(B) About a dozen – Capacitors are energy storage and signal filtering devices used in power supplies for all electronics.

(C) Billions – Capacitors store energy and are also elements of the memory cell in digital devices.

Note that the parallel plate formula only has "geometric" variables. Capacitance is a property of a set of conductors and does not depend on charge or voltage (or any other electric variables)

$$C = \frac{\epsilon_0 A}{d}$$

[Ex. 1] Find the capacitance of a parallel plate capacitor consisting of circular plates 10 cm in radius separated by 1.5 mm.

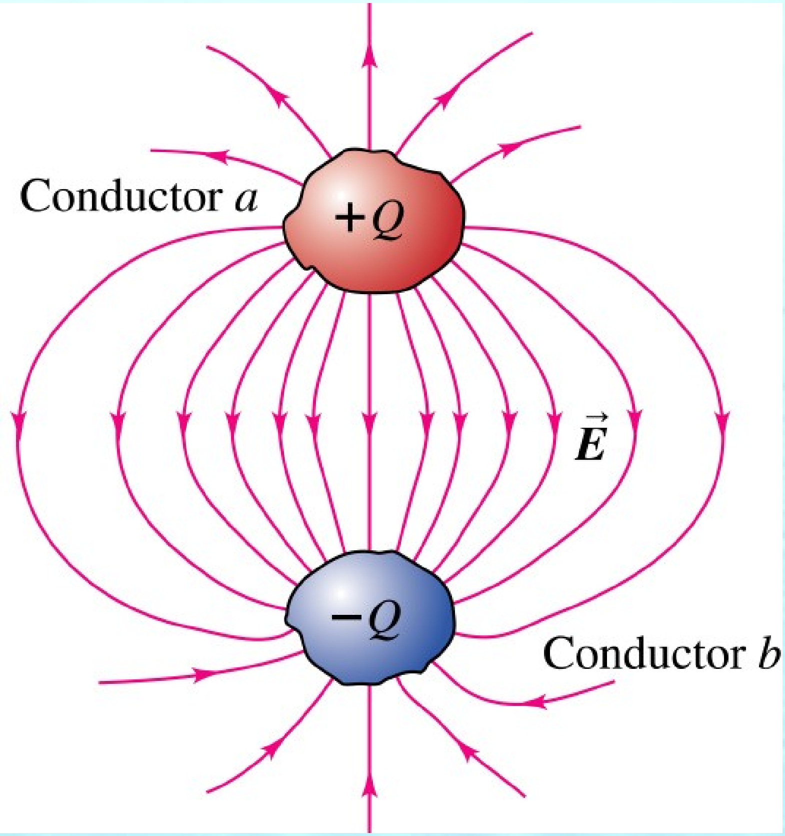
$$C = \epsilon_0 \frac{A}{d}$$

$$\epsilon_0 = 8.86 \times 10^{-12}\ \mathrm{F/m}$$

$$C = \frac{Q}{V}$$

$$U = \frac{1}{2} C V^2$$

The two conductors *a* and *b* are insulated from each other, forming a capacitor. You increase the charge on *a* to +2*Q* and increase the charge on *b* to –2*Q*, while keeping the conductors in the same positions.



What effect does this have on the capacitance *C*?

A. *C* is multiplied by a factor of 4

B. *C* is multiplied by a factor of 2

C. *C* is unchanged

D. *C* is multiplied by a factor of 1/2

E. *C* is multiplied by a factor of 1/4

[Ex. 2] A capacitor's plates hold 1.3 μC when it is charged to 80 V.
What is its capacitance?

$$C = \epsilon_0 \frac{A}{d}$$

$$C = \frac{Q}{V}$$

$$U = \frac{1}{2} C V^2$$

[Ex. 3] A stereo receiver contains a 2500 μF capacitor charged to 35 V.
How much energy does it store?

$$C = \epsilon_0 \frac{A}{d}$$

$$C = \frac{Q}{V}$$

$$U = \frac{1}{2} C V^2$$

You reposition the two plates of a capacitor so that the capacitance doubles.

If the charges $+Q$ and $-Q$ on the two plates are kept constant in this process, what happens to the potential difference V_{ab} between the two plates?

A. V_{ab} is multiplied by a factor of 4

B. V_{ab} is multiplied by a factor of 2

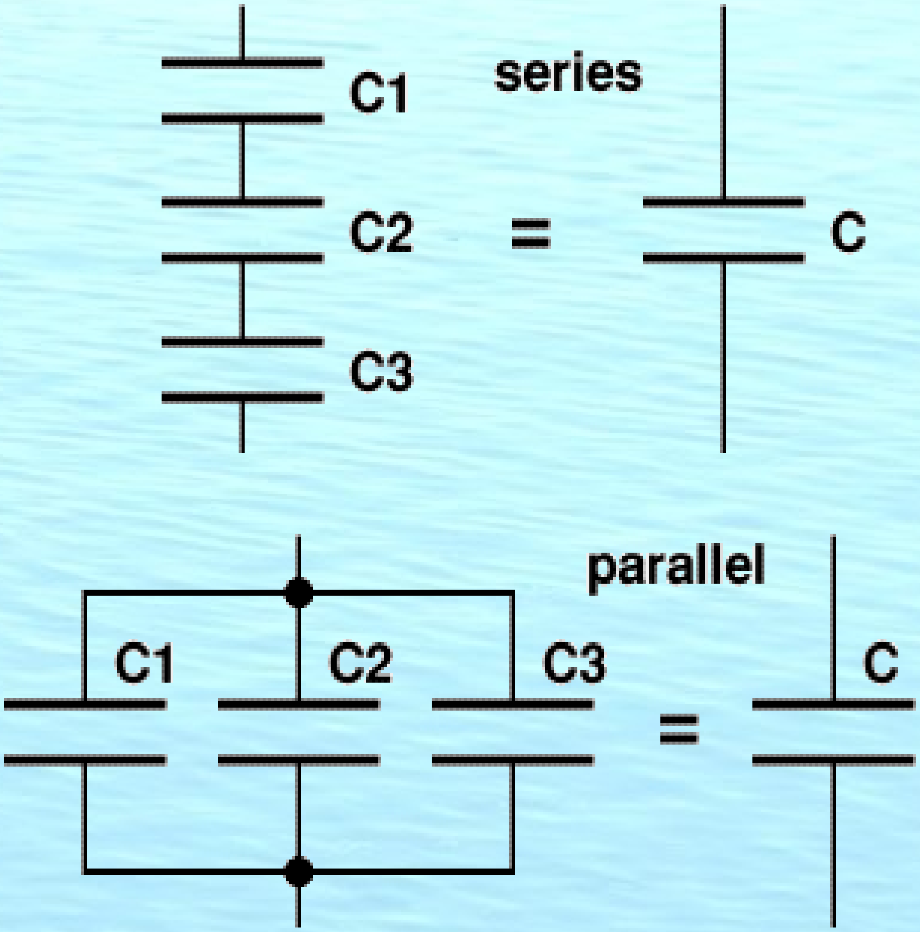
C. V_{ab} is unchanged

D. V_{ab} is multiplied by a factor of 1/2

E. V_{ab} is multiplied by a factor of 1/4

$$Q = C V$$

Capacitors in Series and Parallel

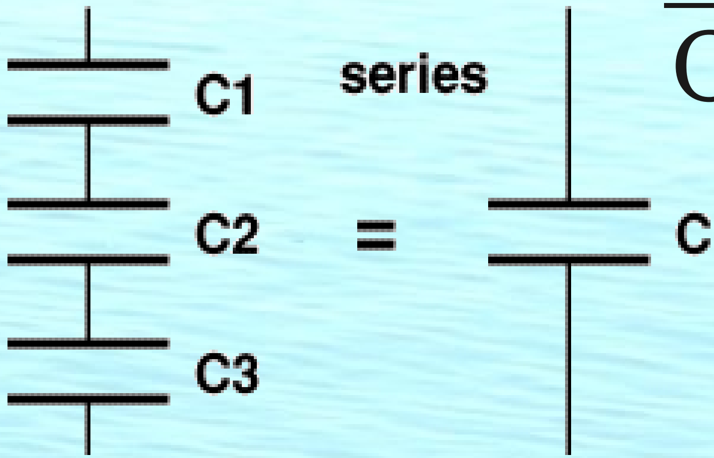


Caps in series have the "bottom wire" or one Connected to the "top wire" Of the next.

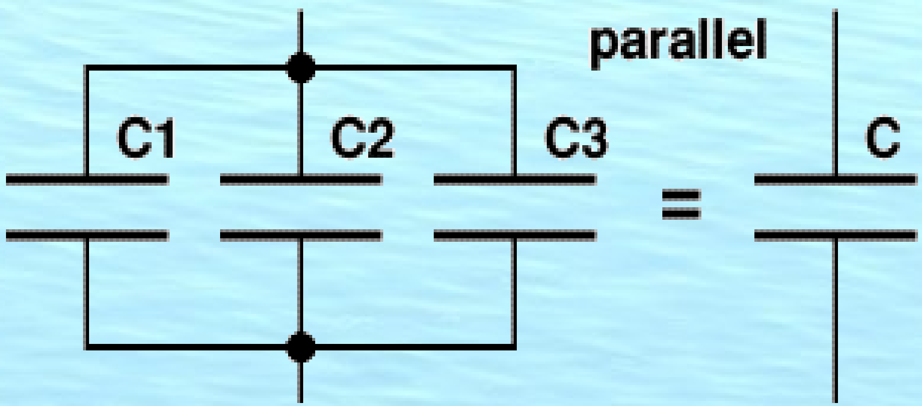
Caps in parallel have all Their tops connected to One wire and all their Bottoms also connected to A second wire.

Caps in series have equal charges

Capacitors in Series and Parallel



$$\frac{1}{C_{series}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$$

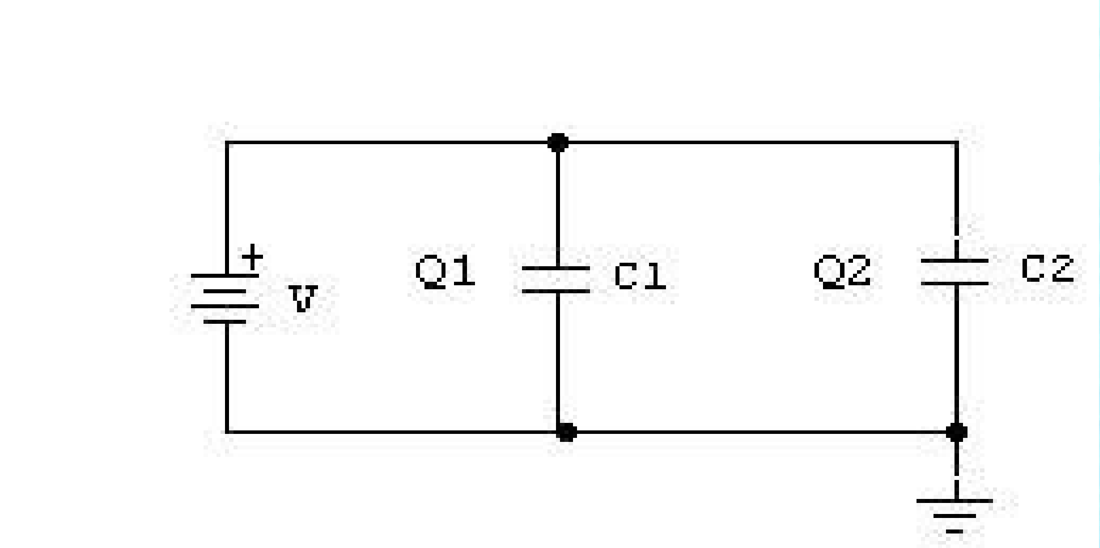


$$C_{parallel.} = C_1 + C_2 + C_3 + \ldots$$

Caps in parallel have equal voltages.

Caps in series have equal charges.

A 12 microfarad capacitor is connected with a 6 microfarad capacitor as shown. The equivalent capacitance of this combination is:



A. C_{eq} = 18 μF

B. C_{eq} = 9 μF

C. C_{eq} = 6 μF

D. C_{eq} = 4 μF

E. C_{eq} = 2 μF

Two capacitors are connected together as shown. What is the equivalent capacitance of the two capacitors as a unit?

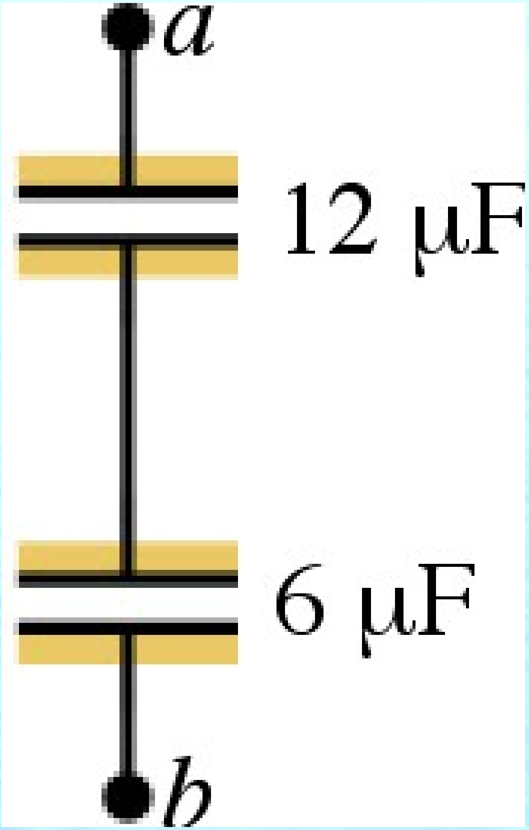
A. C_{eq} = 18 μF

B. C_{eq} = 9 μF

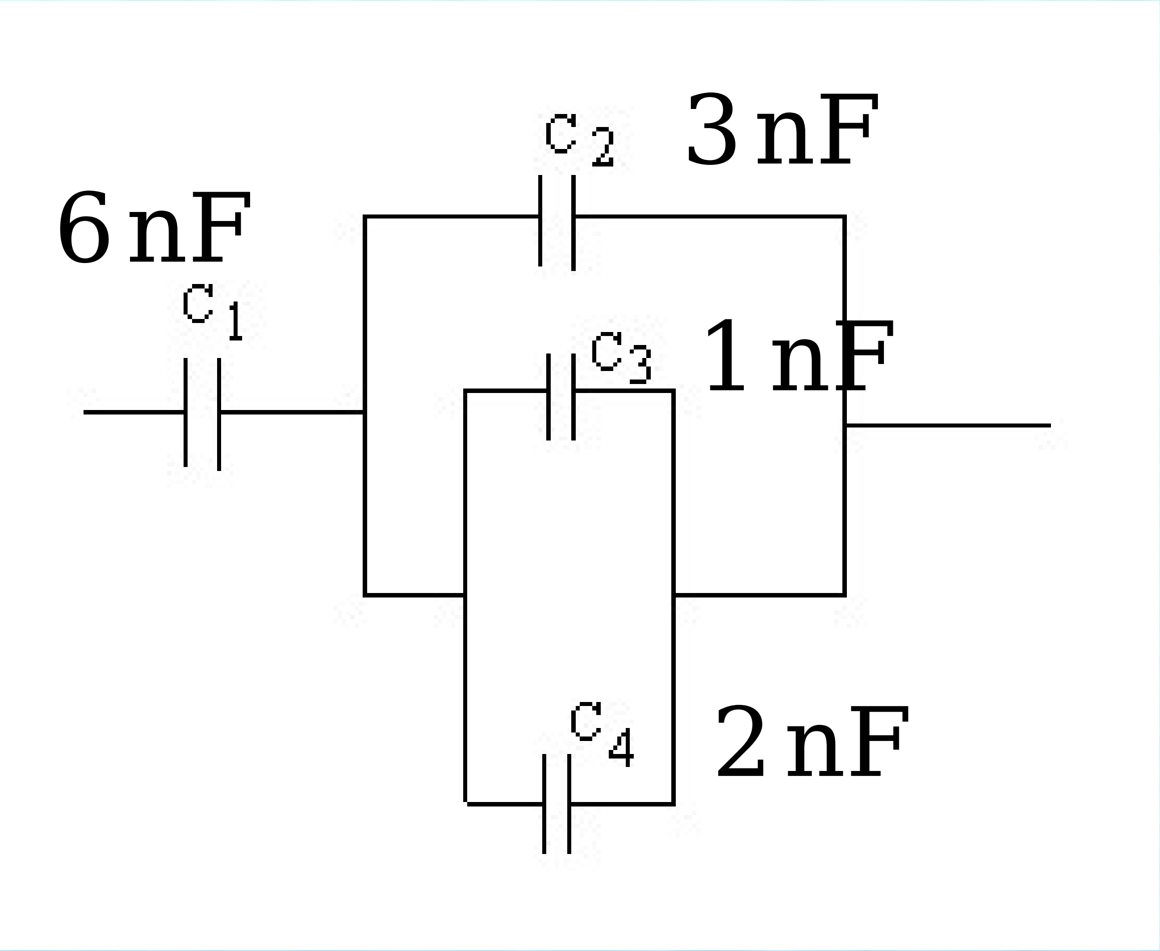
C. C_{eq} = 6 μF

D. C_{eq} = 4 μF

E. C_{eq} = 2 μF



Network of capacitors:
Replace parallel elements with an equivalent cap. Combine that equivalent cap in series with what is left.



[A] 1 nF

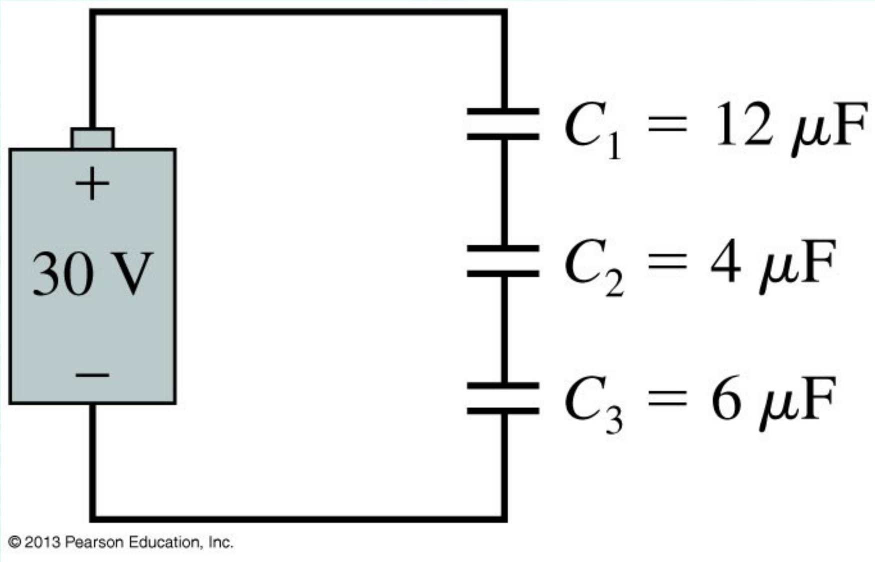
[B] 2 nF

[C] 3 nF

[D] 6 nF

[E] 12 nF

What is the equivalent capacitance?
What is the charge on each capacitor?
What is the voltage across each capacitor?

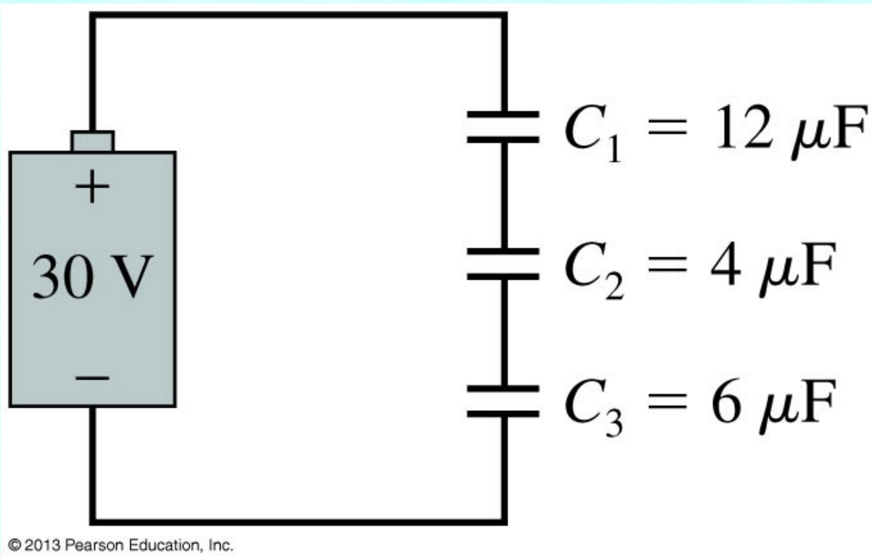


Caps in parallel have equal voltages.

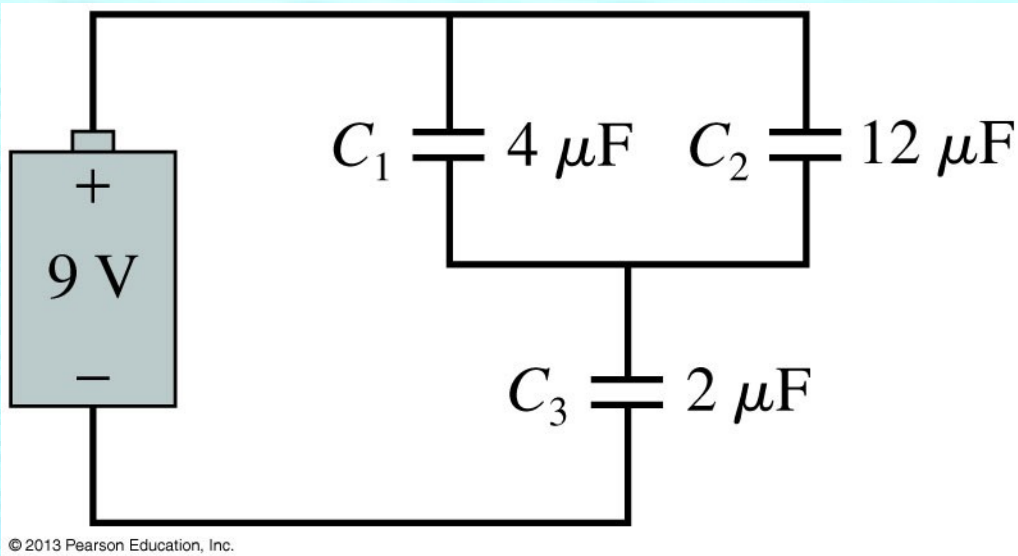
Caps in series have equal charges.

Voltages in series add

What is the equivalent capacitance?
What is the charge on each capacitor?
What is the voltage across each capacitor?



What is the equivalent capacitance?
What is the charge on each capacitor?
What is the voltage across each capacitor?



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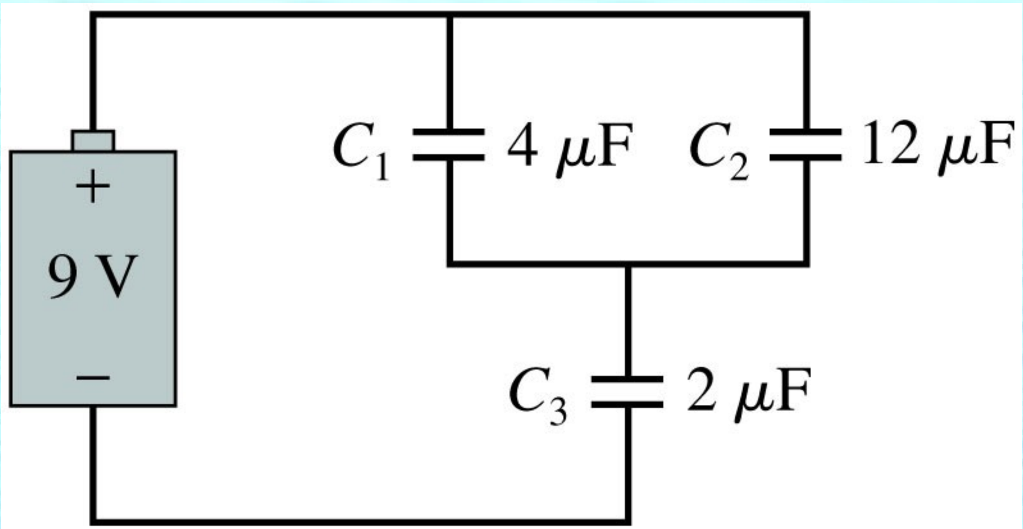
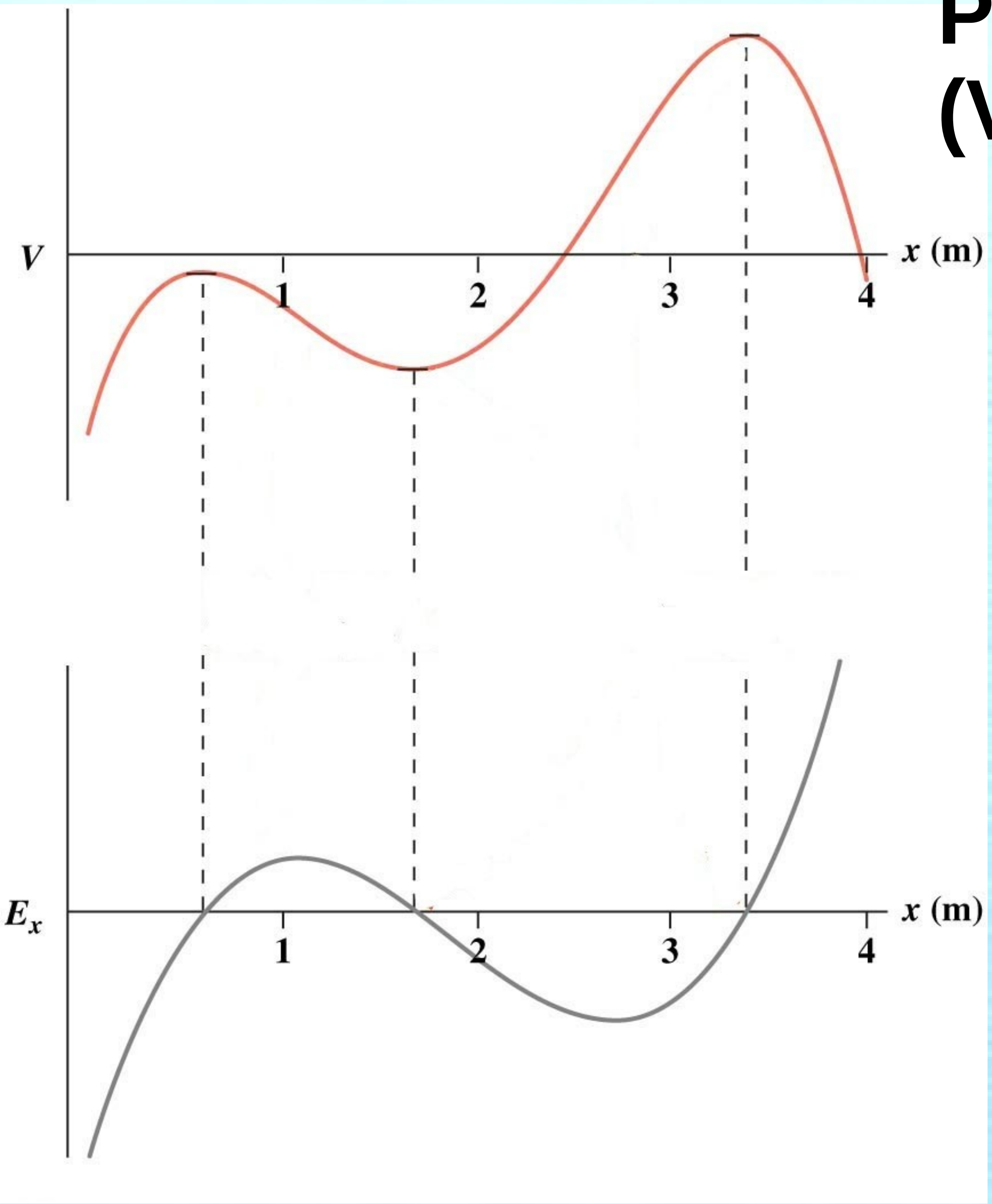
Caps in series have equal charges.

Voltages in series add

What is the equivalent capacitance?
What is the charge on each capacitor?
What is the voltage across each capacitor?



Potential (Voltage) in 1-D



$$V(x) = -\int E_x \, dx$$

$$E_x = -\frac{dV}{dx}$$

Consider a point *P* in space where the electric potential is zero. Which statement is correct?

A. A charge placed at *P* would feel no electric force

B. The electric field near *P* is directed toward *P*

C. the electric field near *P* is directed away from *P*

D. none of the above

E. not enough information given to decide