Physics 122 – Class #20 – (3/26/15)

- Homework/Readings
- Chapter 29, section by section.

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**

Homework

Mastering Physics

29.17, 29.18, 29.19, 29.20, 29.21, 29.25, 29.51, 29.53, 29.54

[Due Tuesday 3/31/2015 at 11:59 pm]

HW-WR-07 29.56, 29.57, 29.17

(due next Tuesday in class)

MP Assignment 9a

29.1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 25, 28, 29, 64, 65

[due Saturday night 4/4]

Reworked Exams

- Reworked exams due next Tuesday (1/3 points back)

- Everyone qualifies

- If you missed last class … come get your exam after class

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 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.

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 =

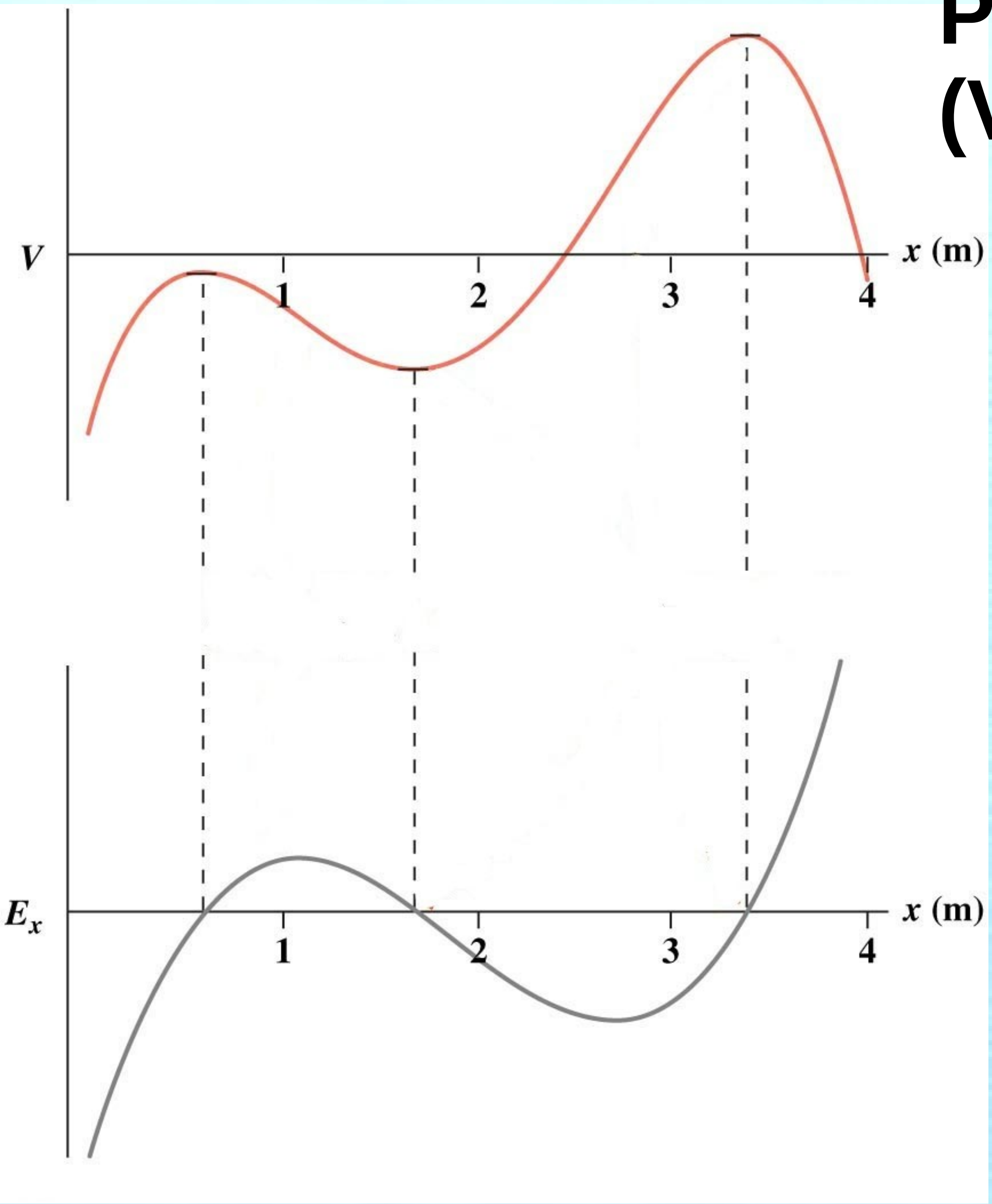
Coulomb/sec x Joules/Coulomb = I V

Chapter 29 – Summary

- 29.1 You can integrate E(x) to get V(x) get E(x) from dV/dx.

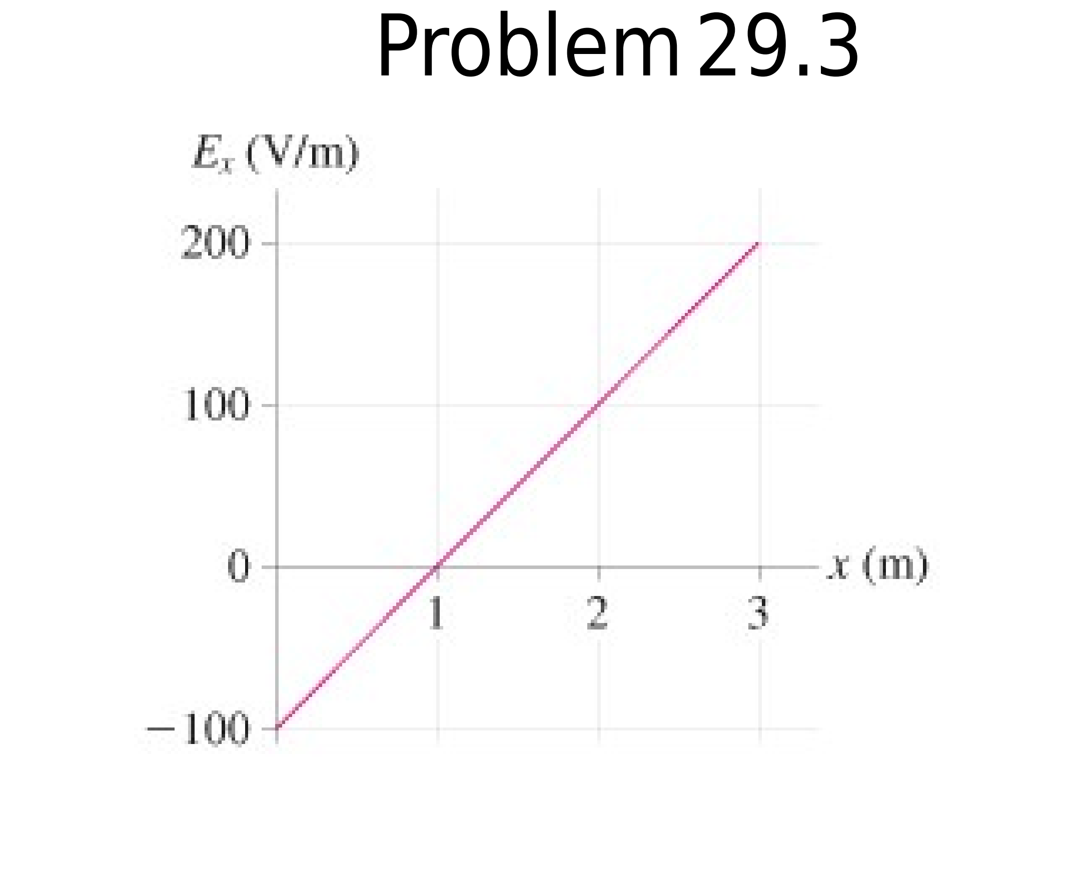
- This allows understanding the formula for a parallel plate capacitor.

Potential (Voltage) in 1-D



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

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



Potential (Voltage) in 1-D

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

Given Ex as at left, what is potential Difference between 2 and 3 meters?

$$y = mx + b$$

$$E_x = 100x - 100$$

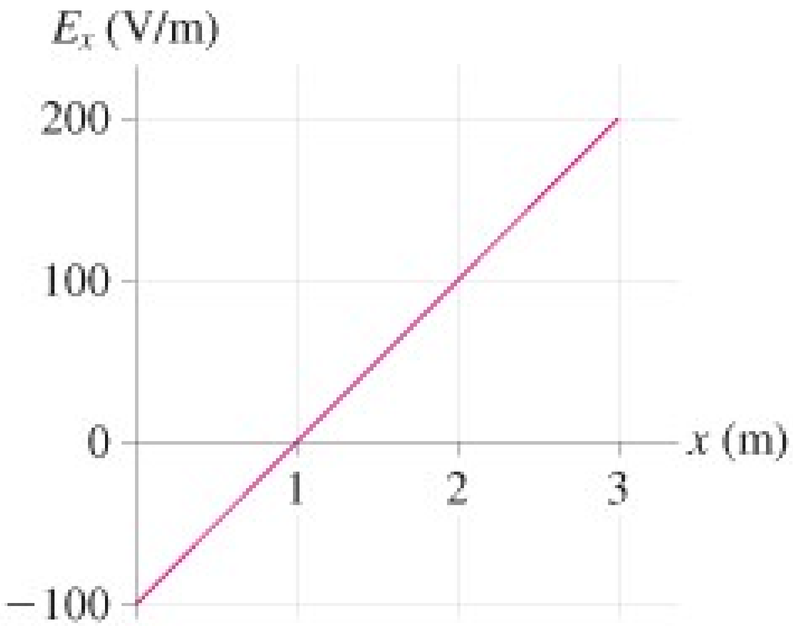
$$V_{23} = -\int_2^3 E_x\,dx = -\int_2^3 (100x - 100)\,dx$$

$$V_{23} = -\int_2^3 (100x - 100)\,dx = -50x^2 + 100x$$

$$V_{23} = -50x^2 + 100x \Big|_2^3$$

$$V_{23} = -(50)(9) + (100)(3) + (50)(4) - (100)(2) = -150\ \text{Volts}$$

Problem 29.3



Potential (Voltage) in 1-D

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

Given Ex as at left, what is potential
Difference between 2 and 3 meters?

Can more easily do this problem
By remembering the integral
Is area under a curve.

Problem 29.4

Potential (Voltage) in 1-D

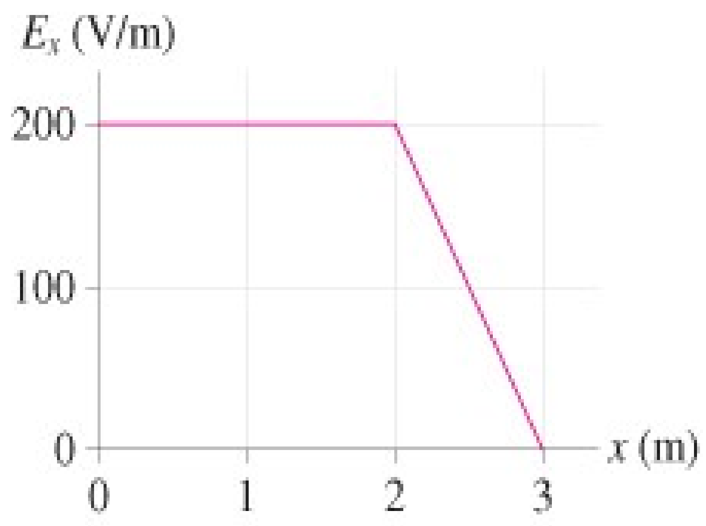
$$V(x) = -\int E_x\,dx$$

If the potential of the origin is V(0) = 100 Volts, what is V(1)? What is V(2)?

What is V(3)?

[A] 0 V
[B] -100 V
[C] -300 V
[D] -400 V
[E] -450 V
[F] -500 V

Problem 29.4



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Electric field from voltage

Given $V(x) = 8x^2 - 7$
what is the
Electric field at x=1 m?

[A] 1 V
[B] -1 V
[C] -9 V
[D] 16 V
[E] -16 V

You are told that the electric potential is zero At some point “P”. Which statement is correct?

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

B. The electric field at *P* is also zero.

C. The electric field at *P* is negative

D. Both A and B

E. not enough information given to decide

Chapter 29 – Summary

- 29.2 You “manufacture” potential with a battery, or a Van de Graaf … or a power plant!

Van de Graaf Generator

- Charges are literally carried up on a belt from the base (ground) to the sphere on top of generator.

- Since there are already charges on top, there is an electric field and work must be done to move the charges toward the field

- Whenever you have a voltage source, work was done against electric field.

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!

Electric Power Plants

Tinyurl.com/fourcornerspowerplant

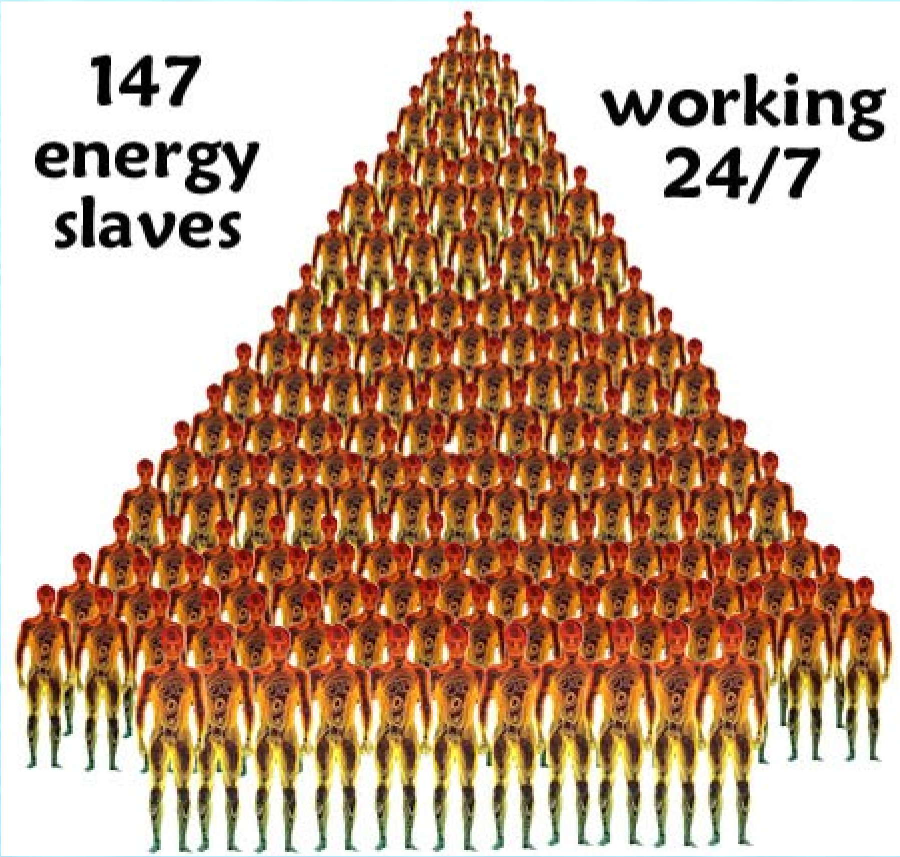
http://tinyurl.com/feedingacoalfiredplant

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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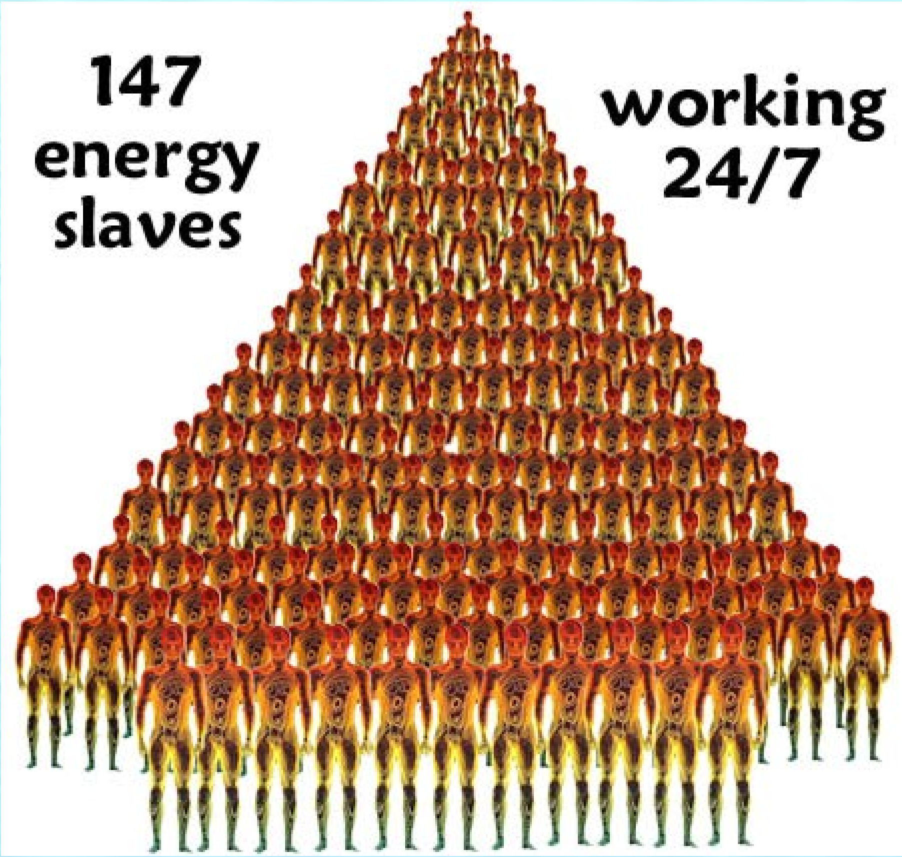


Our wonderful lifestyle is Sustained by "energy slaves"

You are all Pharoahs.

Chapter 29 – Summary

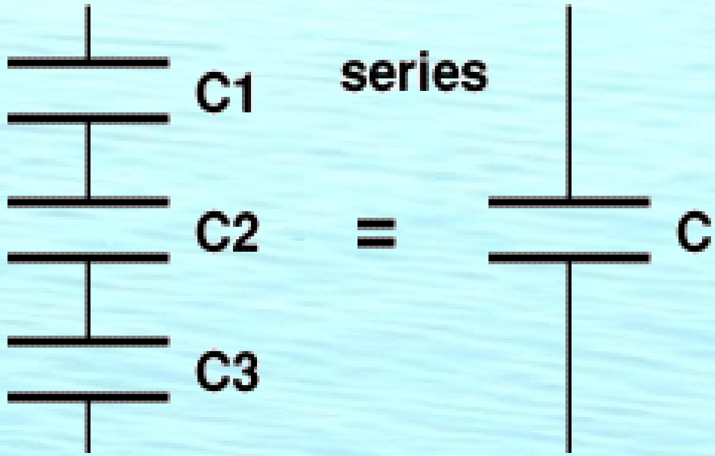
- 29.3 E is the “gradient” of potential AND Potentials add in series.
- 29.4 Every point in a conductor is at the same potential.

Chapter 29 – Summary

- 29.5 Q=CV

  Capacitances in Parallel Add.
- You need a reciprocal formula for capacitances in series.

Capacitors in Series and Parallel

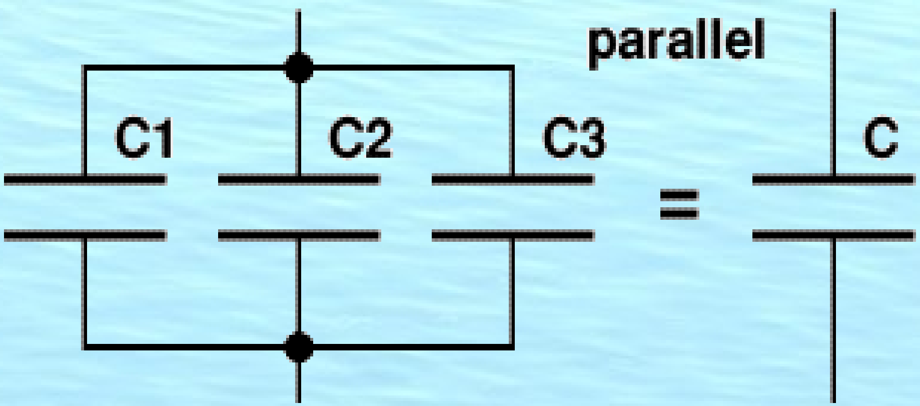


Caps in series have the

"bottom wire" or one

Connected to the "top wire"

Of the next.



Caps in parallel have all

Their tops connected to

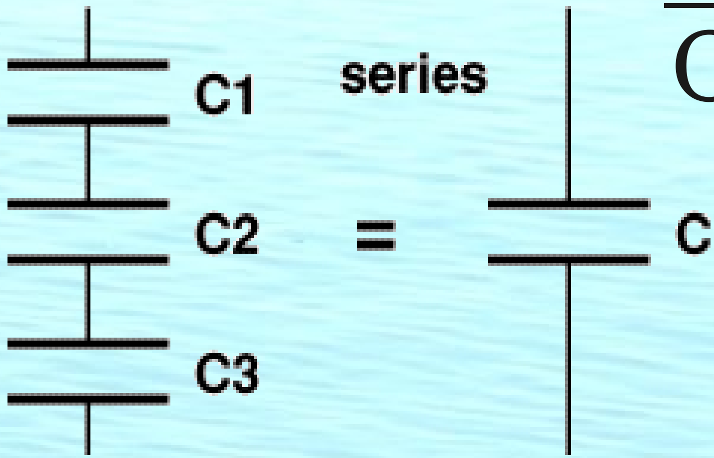
One wire and all their

Bottoms also connected to

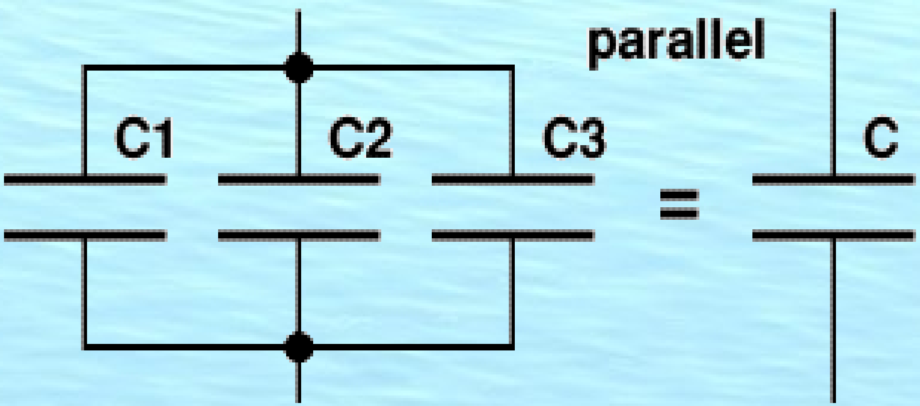
A second wire.

Caps in series have equal charges

Capacitors in Series and Parallel



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

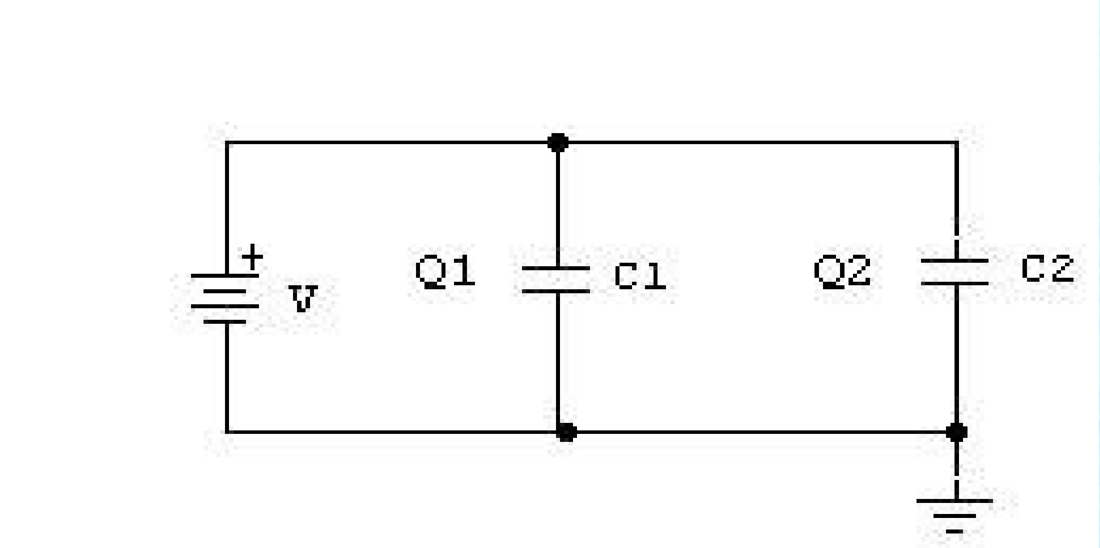


$$C_{parallel.} = C_1 + C_2 + C_3 + \ldots$$

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

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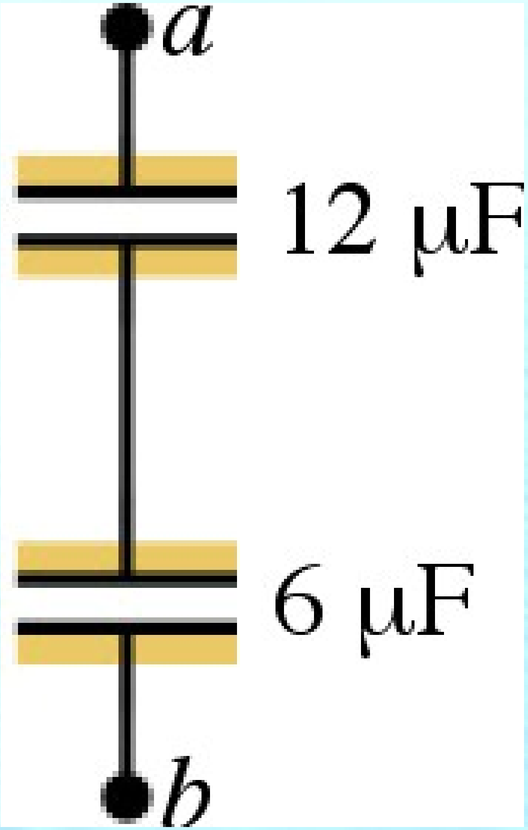


Chapter 29 – Summary

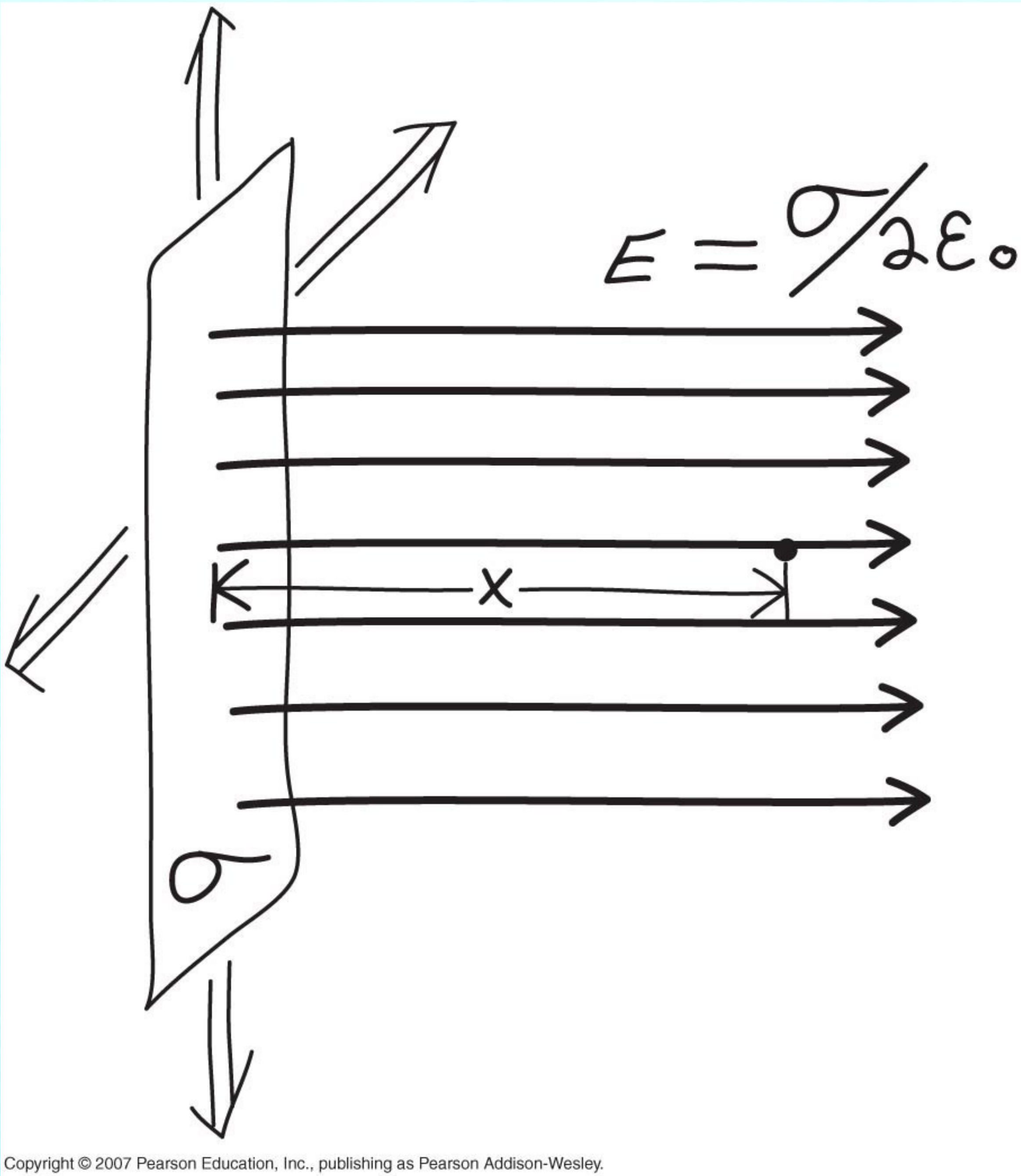
- 29.6 Capacitors store energy and charge
- 29.7 Dielectric materials let you store more energy and charge in the same space then using air or a vacuum.

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

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)



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:

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

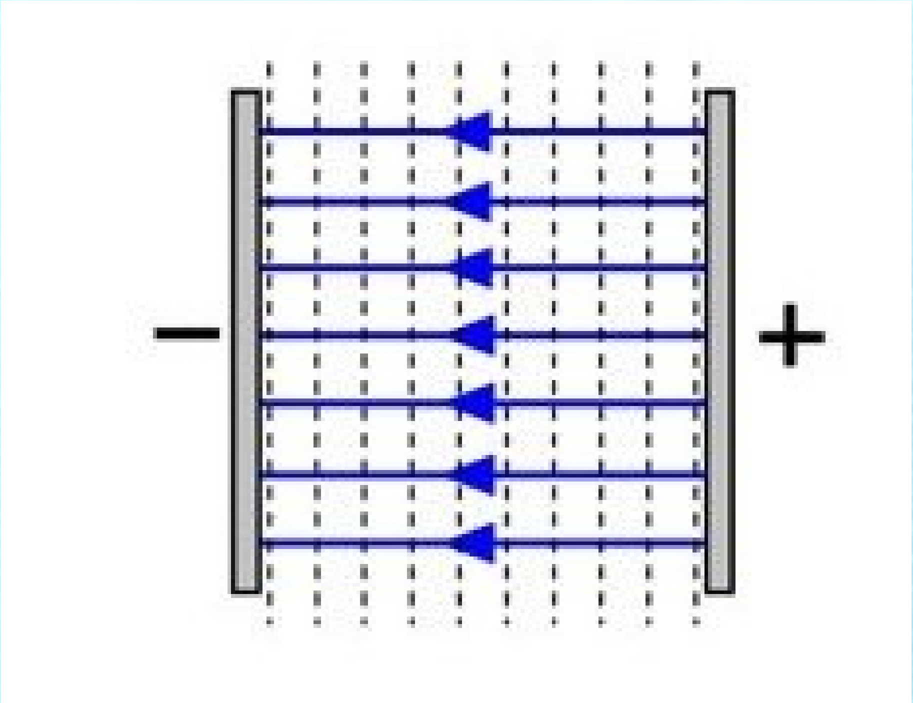
$$[C]\ V = \frac{\sigma}{2\epsilon_0}x \qquad [D]\ V = -\frac{\sigma}{2\epsilon_0}x$$

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

$$[1]\ Q = CV$$

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

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.

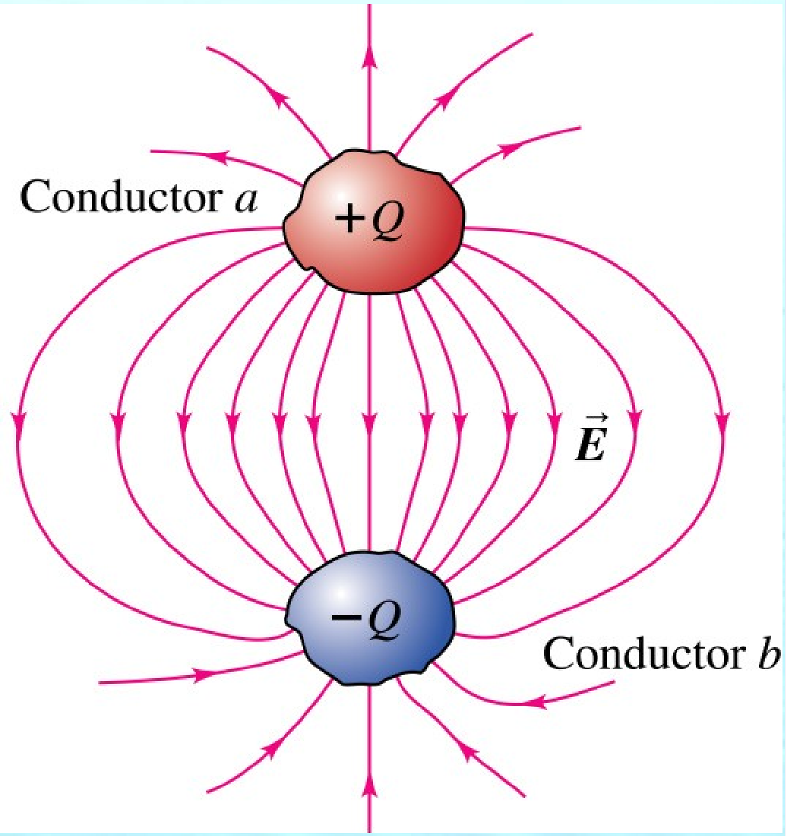
$$C = \epsilon_0 \frac{A}{d}$$

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

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

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

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

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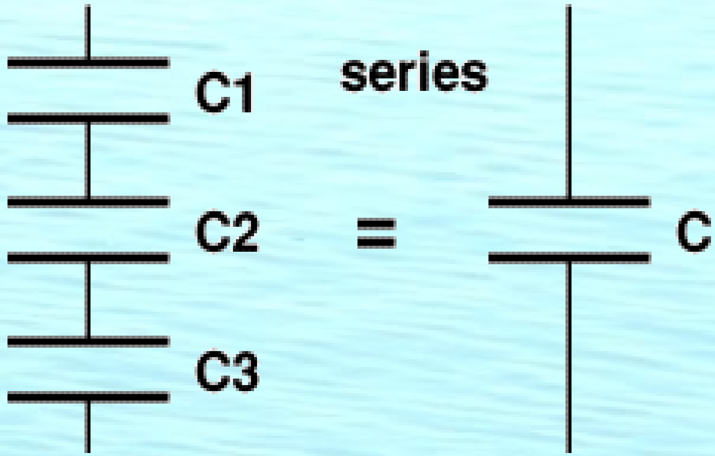
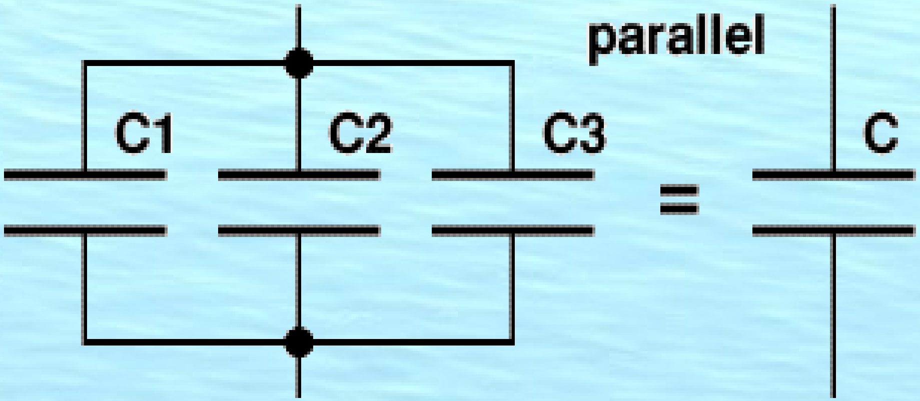
$$Q = CV$$

Capacitors in Series and Parallel





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Connected to the “top wire”
Of the next.

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Their tops connected to
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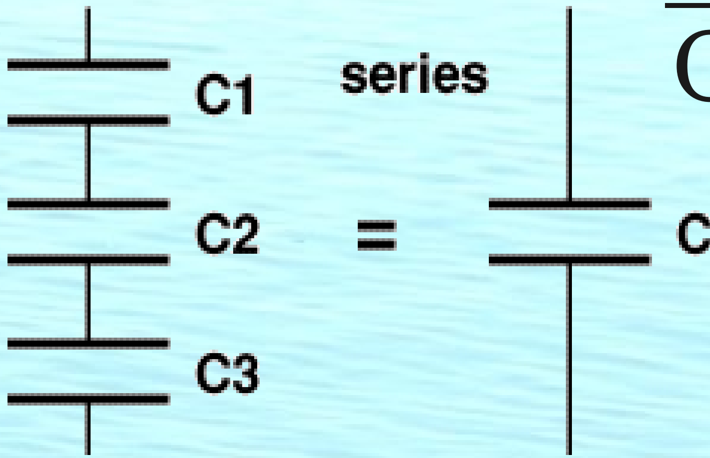

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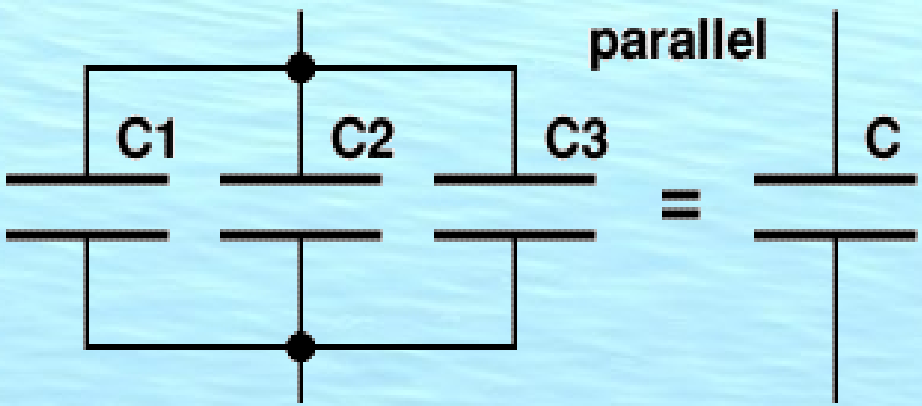

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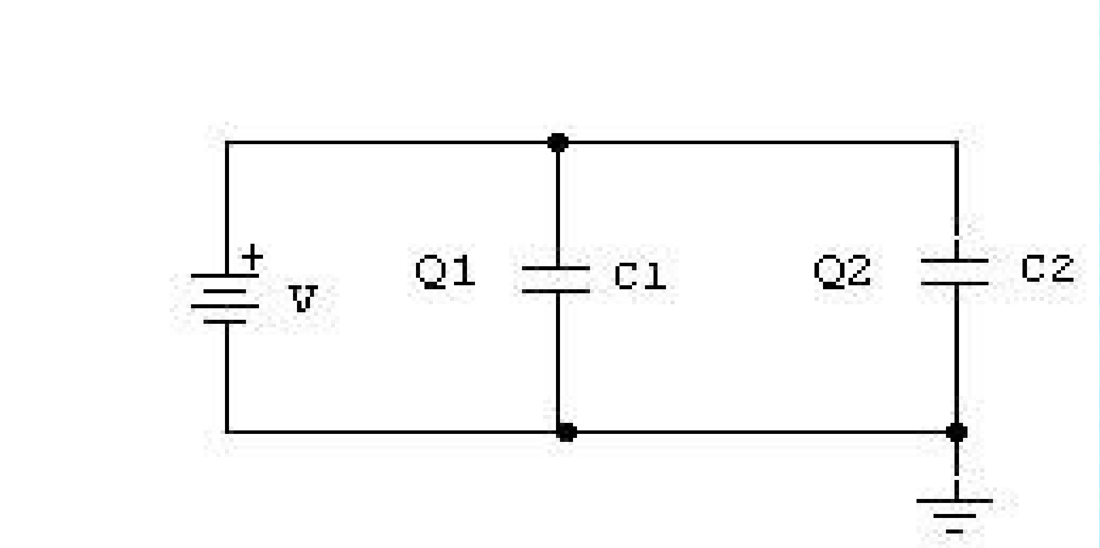

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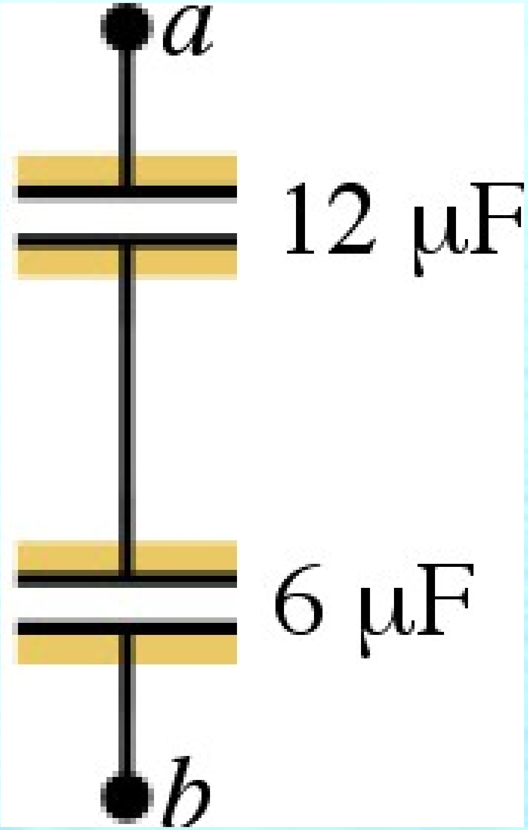

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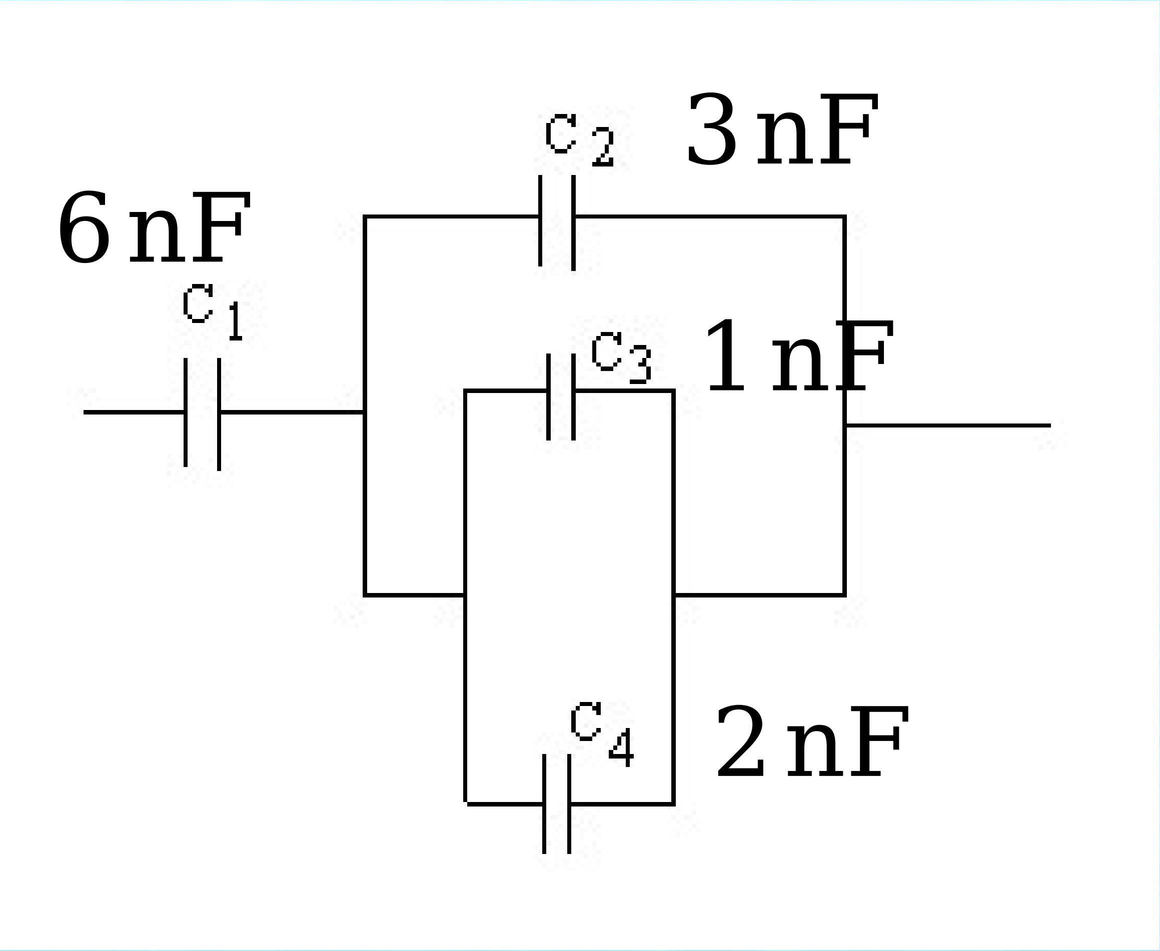
Network of capacitors:
Replace parallel elements with an equivalent cap. Combine that equivalent cap in series with what is left.



[A] 1 nF

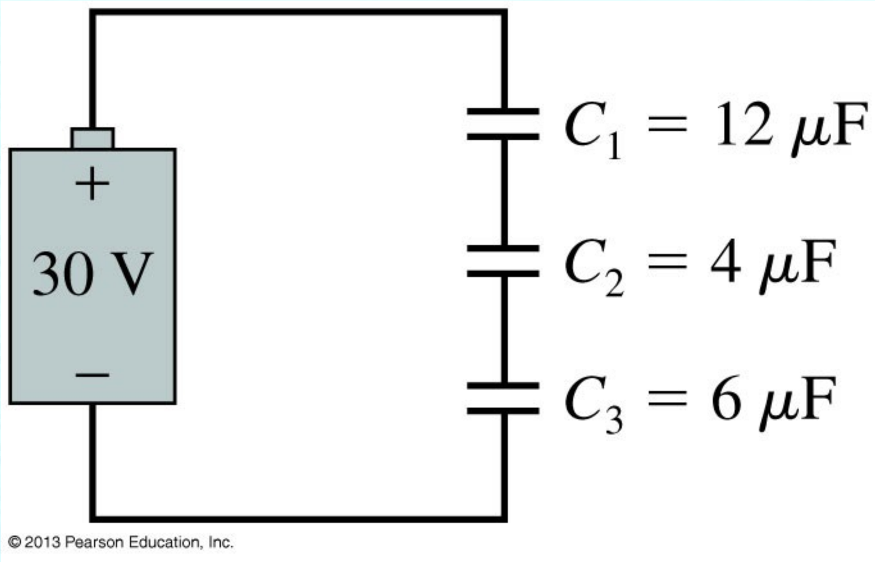
[B] 2 nF

[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

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What is the charge on each capacitor?
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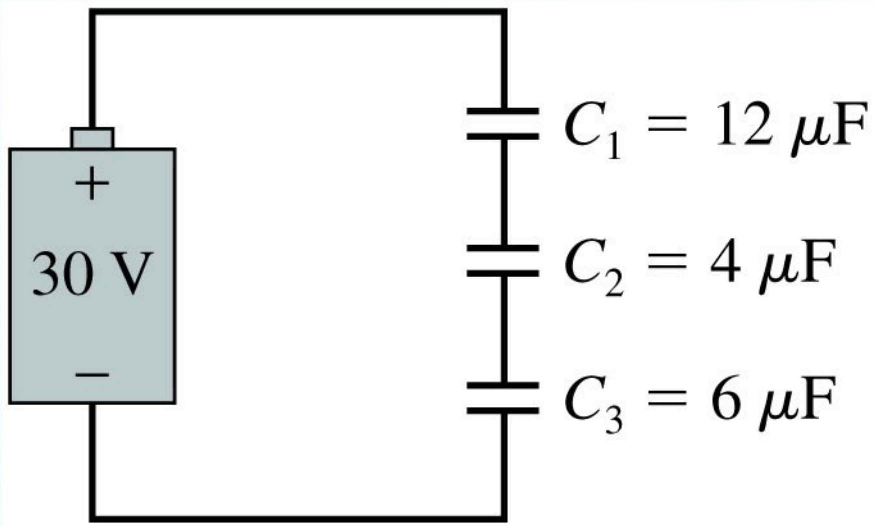

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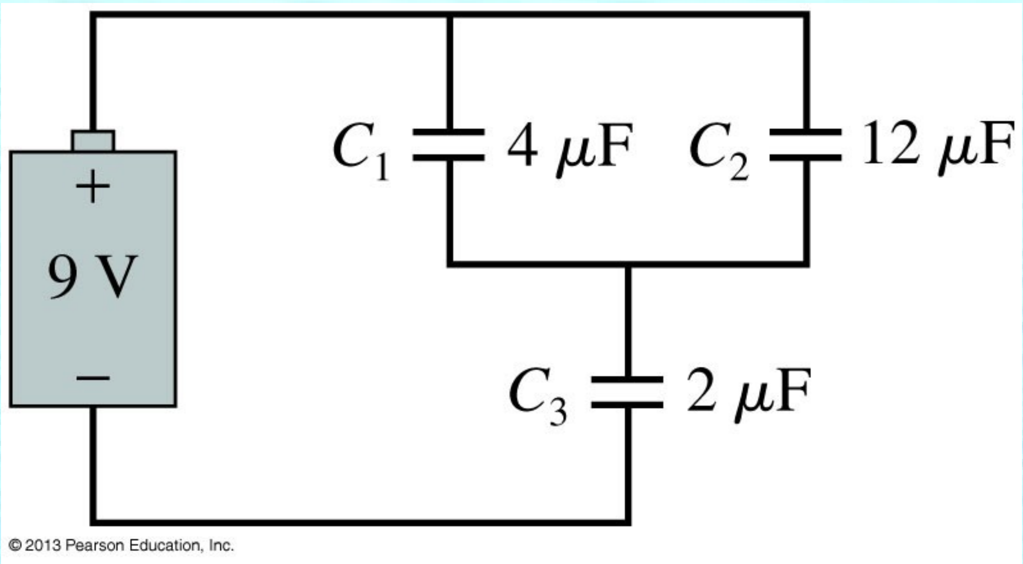

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