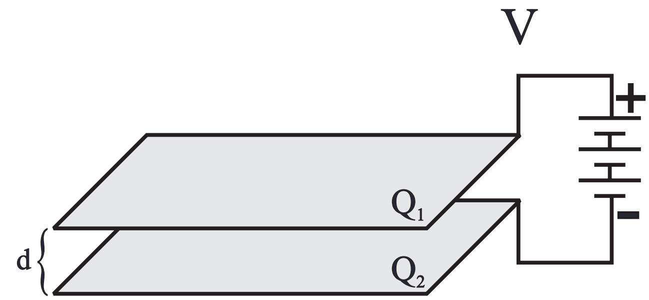
PHYSICS HOMEWORK #143 ELECTROSTATIC POTENTIAL
CALCULATING POTENTIAL VIA INTEGRATION

$$\Delta V = \int_b^a E \cdot dl$$

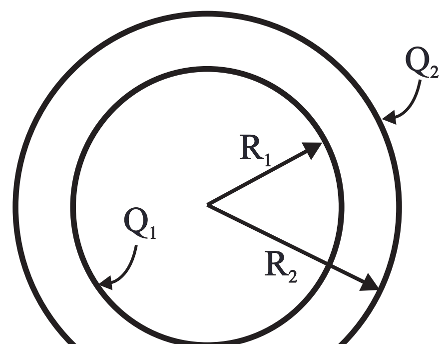
[Unless stated otherwise assume that absolute potential is zero at infinity!]

1. Consider two horizontal, parallel plates, each with an area of 3.00 m^2, separated by a distance of d = 3.50 cm. These two plates are connected to a battery and, as a result, the upper plate gains a charge of Q_1 = 12.0 μC and the lower plate gains a charge of Q_2 = -12.0 μC.



   a. What will be the strength of the electric field in the area between these two plates?
   b. What will be the strength of the electric field in the area outside of these two plates?
   c. What will be the potential difference between these two plates?
   d. How much work would be done on an electron in moving it from the positive plate to the negative plate?
   e. Suppose that this electron is then released and is allowed to accelerate back to the positive plate, what will be the velocity of the electron just as it reaches the positive plate?

2. Consider two concentric, conducting spherical shells with radii of R_1 = 4.00 cm and R_2 = 6.00 cm as shown in the diagram to the right. The inner shell contains a charge of Q_1 = -6.00 μC and the outer shell contains a charge of Q_2 = +12.0 μC.



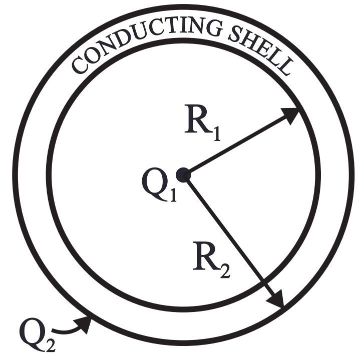
   a. What will be the electrostatic potential of the the outer shell?
   b. What will be the potential difference between the inner shell and the outer shell?
   c. What will be the electrostatic potential of the inner shell?
   d. What will be the electrostatic potential at the center of these two shells?
   e. How much work must be done to transfer a single electron from the inner shell to the outer shell?
   f. How much work would be required to bring a proton from infinity to the outer shell?
   Suppose that the radius of the outer shell increases until R_2 becomes 9.00 cm.
   g. What will be the potentials of the outer and inner shells?
   h. What will be the new potential difference between these two shells?

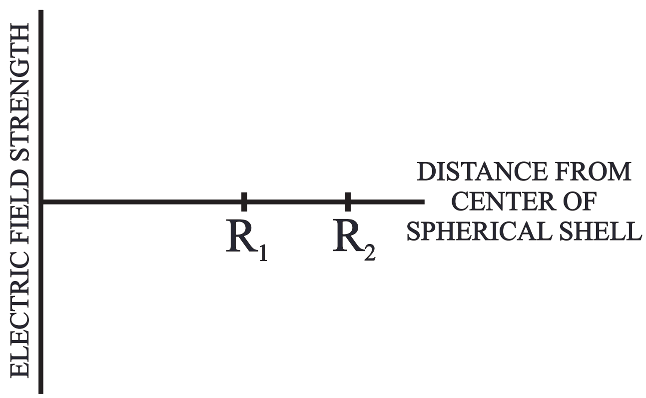
3. Consider two concentric, conducting cylindrical shells which have radii of R_1 = 4.00 cm and R_2 = 6.00 cm and are L = 35.0 m long [same diagram as above]. The inner shell contains a charge of Q_1 = -12.0 μC and the outer shell contains a charge of Q_2 = +12.0 μC.
   a. What will be the electrostatic potential of the the outer shell?
   b. What will be the potential difference between the outer shell and the inner shell?
   c. What will be the electrostatic potential of the inner shell?
   d. What will be the electrostatic potential at the center of these two shells?
   e. How much work must be done to transfer a single electron from the outer shell to the inner shell?
   f. How much work would be required to bring a proton from infinity to the outer shell?

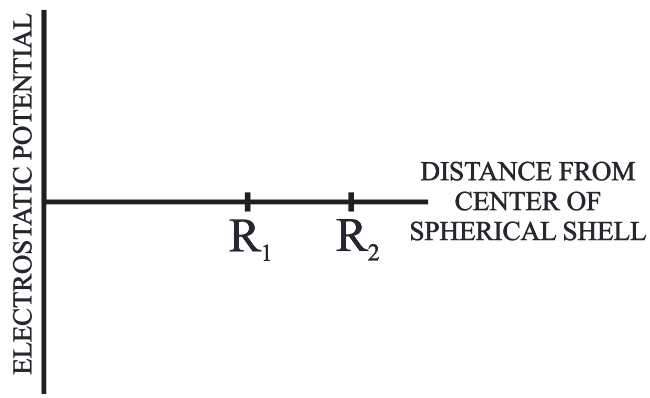
Answers to opposite side: 4a. 1.20 x 10^6 Volts b. zero c. 1.20 x 10^6 Volts d. -3.43 x 10^6 Volts 4e. infinity 4h. 0.027 m 5a. [L to R] -5.65 x 10^4 N/C, 1.70 x 10^5 N/C, -5.65 x 10^4 N/C, 5.65 x 10^4 N/C 5b. [L to R] 5.65 x 10^4 Volts, 5b. -2.83 x 10^4 Volts, 2.83 x 10^4 Volts c. 8.48 x 10^4 Volts d. 2.83 x 10^4 Volts e. 4.52 x 10^{-15} J

PHYSICS HOMEWORK #144 ELECTROSTATIC POTENTIAL
CALCULATING POTENTIAL VIA INTEGRATION

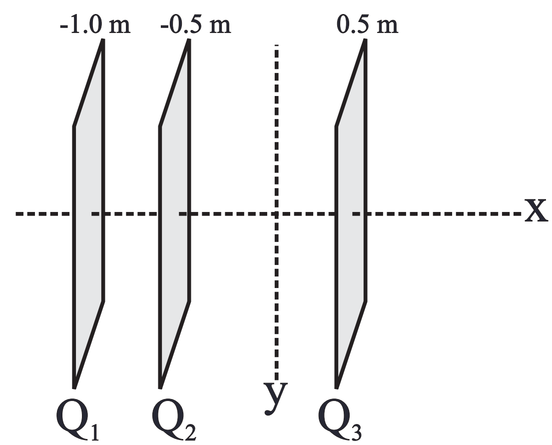
4. Consider a conducting spherical conducting shell, which has an inner radius of R_1 = 7.00 cm, an outer radius of R_2 = 9.00 cm and contains a charge of Q_2 = +18.0 μC. This shell, in turn, encloses a point charge of Q_1 = -6.00 μC located at its center as shown in the diagram at the right.
   a. What will be the electrostatic potential of the outside of the conducting shell?
   b. What will be the potential difference between the inside of the conducting shell and the outside of the conducting shell?
   c. What will be the electrostatic potential on the inside of the conducting shell?
   d. What will be the electrostatic potential at a point 1.0 cm from the central charge?
   e. What will be the electrostatic potential at the location of Q_1?
   f. On the graph below sketch the electric field strength as a function of distance from Q_1.
   g. On the graph below sketch the electrostatic potential as a function of distance from Q_1.
   h. Where, other than infinity, will the absolute potential be zero?







5. Consider three, vertical, parallel, conducting plates as shown to the right. Each plate has an area of 3.00 m^2. The first plate contains a charge of Q_1 = +6.00 μC and is located at x = -1.00 m. The second plate contains a charge of Q_2 = -6.00 μC and is located at x = -0.50 m. The third plate contains a charge of Q_3 = +3.00 μC and is located at x = 0.500 m. Assume that the absolute electrostatic potential is zero at the origin.
   a. Determine the electric field everywhere.
   b. What will be the electrostatic potential of each plate?
   c. What will be the potential difference between plate #1 and plate #2?
   d. What will be the potential difference between plate #1 and plate #3?
   e. How much work would be required to move a proton from plate #1 to plate #3?

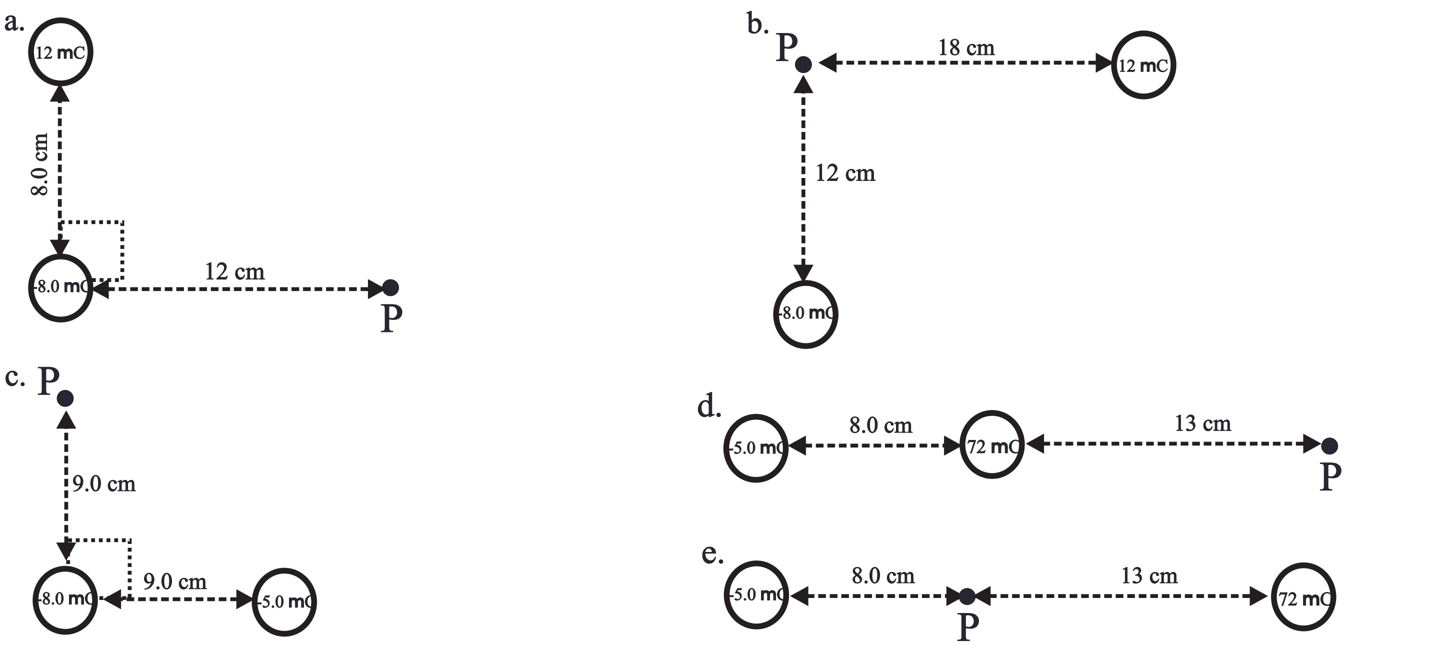


Answers to opposite side #105: 1a. 4.50 x 10^5 N/C b. zero c. 15,800 Volts d. 2.50 x 10^{-15} J e. 7.50 x 10^7 m/s
2a. 900,000 Volts b. -450,000 Volts 2c. 450,000 Volts d. 450,000 Volts e. -7.2 x 10^{-14} J f. 1.44 x 10^{-13} J
2g. 600,000 Volts h. 750,000 Volts 3a. zero b. -2500 Volts c. -2500 Volts d. -2500 Volts e. 4.0 x 10^{-16} J

PHYSICS HOMEWORK #145 ELECTROSTATIC POTENTIAL
ELECTROSTATIC POTENTIAL ENERGY

6. What will be the electrostatic potential of a point **P** which is both 12.0 cm from a 25.0 μC charge and 6.0 cm from a 50 μC charge?

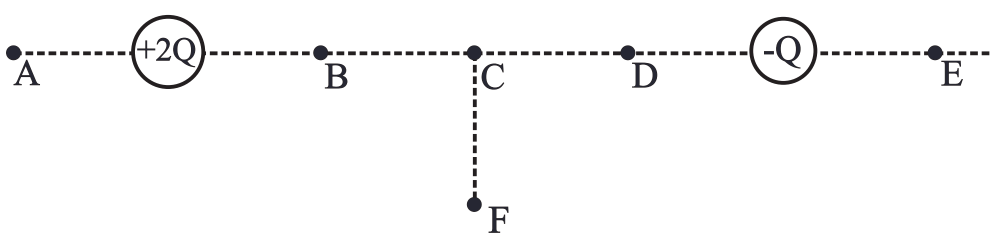
7. Determine the **electrostatic potential** at point **P** in each of the following diagrams.



8. Suppose that in each diagram above a 7.00 μC charge is to be moved from **infinity** to point **X**. In each case above, determine how much **work** would be required to place the 7.00 μC charge at point **X**.

9. What will be the **electrostatic potential energy** of each set of charges above? [including the 7.0 μC charge!]

10. Each of the following questions refers to the diagram below.



a. At which point in the above diagram will the **electric field strength** be the **greatest**?
b. At which point in the above diagram will the **electrostatic potential** be the **greatest**?
c. At which point in the above diagram will the **electric field strength** be the **weakest**?
d. At which point in the above diagram will the **electrostatic potential** be the **least**?

ANSWERS TO THE OPPOSITE SIDE: 1a. 37.5 μF b. 2700 μC 2. 16 μF 3. 1260 μC 4. 30,000 μC 5. 0.015 μF 6. 0.22 μF 7. 20.3 μF 8. 238 m^2 9. 400 μF 10. 155 μF 11. 500 μF 12. 0.030 J 13. 14.4 J 14. 144 Volts 15. 161 μF

PHYSICS HOMEWORK #146 ELECTROSTATIC POTENTIAL
CAPACITORS & CAPACITANCE

$$C = \frac{q}{V} = \frac{\varepsilon \cdot A}{d} \quad \varepsilon = \varepsilon_o \cdot K \qquad \varepsilon_o = \mathbf{8.85 \cdot 10^{-12}} \cdot \frac{Farad}{m}$$

1. A given capacitor is rated to store 450 μC of charge whenever a potential difference of 12.0 Volts is applied.
   a. What is the capacitance of this capacitor?
   b. How much charge will this capacitor store when a potential difference of 72.0 Volts is applied?

2. What is the capacitance of capacitor which can store 720 μC of charge whenever a potential difference of 45.0 Volts is applied?

3. How much charge can be stored in a capacitor rated at 210 μF, if a potential difference of 6.00 Volts is applied?

4. How much charge can be stored in a 2000 μF capacitor when a potential difference of 15.0 Volts is applied?

DIELECTRIC MATERIAL	DIELECTRIC CONSTANT K
AIR	1.0
PARAFFIN	2.2
POLYETHYLENE	2.3
POLYSTYRENE	2.5
HARD RUBBER	2.8
MICA	6.0
GLASS	8.0

5. A parallel plate capacitor is made of two parallel plates, each of which has an area of 2.0 m^2, and which are separated by 1.20 mm of air. What is the capacitance of this capacitor?

6. What will be the capacitance of a parallel plate capacitor which is made from two parallel plates, each with an area of 3.5 m^2, which are separated by 0.85 mm of mica ?

Series

$$\frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{C_t}$$

Parallel

$$C_1 + C_2 = C_t$$

Energy

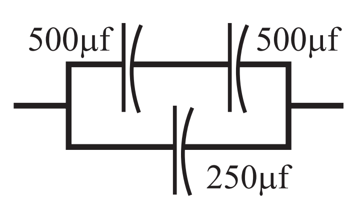
7. What will be the capacitance of a parallel plate capacitor consisting of two two parallel plates, each of which has an area of 13.3 m^2, which are separated by 0.0145 mm of polystyrene?

8. A parallel plate capacitor is to be made from two conducting plates separated by 0.022 mm of polyethylene. This capacitor is to have a total capacitance of 220 μF. What should the area of each plate of this capacitor be?

9. What will be the total capacitance if a 250 μF capacitor is connected in parallel with a 150 μF capacitor?

10. What will be the total capacitance if a 240 μF capacitor is connected in series with a 440 μF capacitor?

11. What will be the total capacitance if two 500 μF capacitors are connected is series with each other but which are connected in parallel with a 250 μF capacitor? See diagram at the right!



12. How much energy will be stored in a 420 μF capacitor to which a potential difference of V = 12.0 Volts has been applied?

13. How much energy would be stored in a 2000 μF capacitor attached to a 120 Volt power supply?

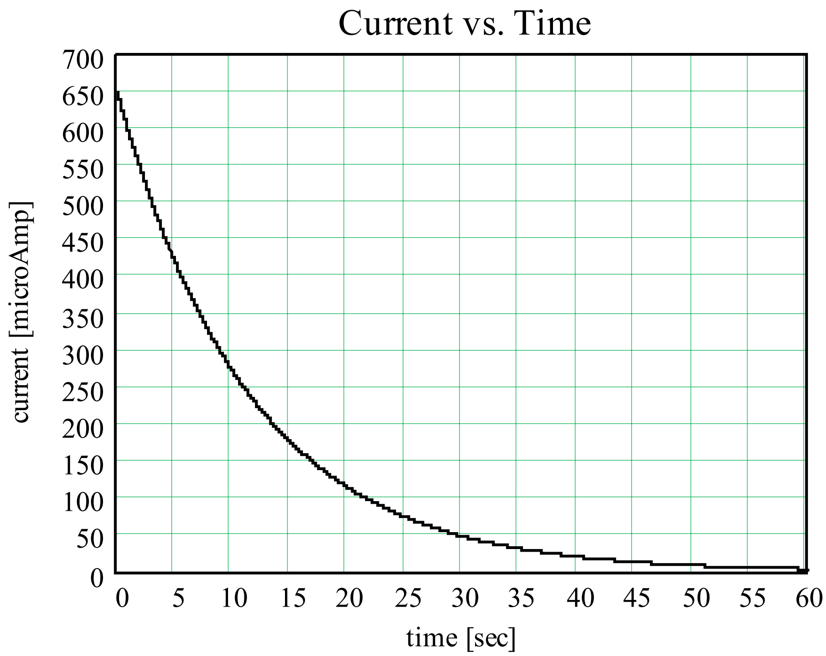
14. A capacitor is rated at 1200 μF. What potential difference should be applied to this capacitor so that the energy stored in this capacitor is 12.4 Joules?

15. What will be the total capacitance if a 350 μF, a 520 μF and a 700 μF capacitor are all connected in series?

Answers to opposite side: 6. 9,400,000 Volts 7a. 1.5 x 10^5 Volts b. 0.0 Volts c. -1.15 x 10^6 Volts d. 4.77 x 10^6 Volts 7e. 4.42 x 10^6 Volts 8a. 1.05 J b. 0.0 J c. -8.08 J d. 33.4 J e. 30.9 J 9a. -9.75 J b. -3.99 J c. -4.08 J 9d. -7.10 J e. 15.5 J 10a. B b. A c. E d. E

PHYSICS HOMEWORK #147 ELECTROSTATIC POTENTIAL
DISCHARGING CAPACITORS

16. A capacitor with a capacitance C is attached to a power supply which has a potential V and is then fully charged. This capacitor is then attached to a simple series circuit consisting of a galvanometer and a 13,000 Ω resistor. The graph to the right represents the current flowing out of this capacitor as a function of time through the galvanometer.
    a. What was the initial current flowing out of the capacitor?
    b. What was the initial voltage across the capacitor?
    c. What is the time constant for this circuit?
    d. Write an equation describing the current flowing out of this circuit as a function of time?
    e. Using the equation derived in d above predict the current flowing out of this capacitor after t = 30 seconds and compare to the value on the graph.
    f. What was the total charge contained in this capacitor?
    g. What is the capacitance of this capacitor?
    h. How much charge will be stored in this capacitor after t = 20 seconds?
    i. What will be the current flowing out of this capacitor after t = 85 seconds?



17. A capacitor, which has a capacitance of 470 μF, is attached to a 6.00 Volt battery and is fully charged. This capacitor is then removed from the battery and is attached in series to a 1500 Ω resistor.
    a. What is the time constant for this circuit?
    b. What will be the total charge stored in this capacitor?
    c. What will be the initial current flowing through this circuit?
    d. What will be the current flowing through this circuit after 1.5 seconds?
    e. How long will it take for the current flowing in this circuit to fall to 1% of its initial value?

18. A 220 μF capacitor is charged up by a 12.0 Volt battery.
    a. What will be the charge stored on this capacitor after being charged up?
    This capacitor is then attached to a second capacitor, which is initially uncharged and has a capacitance of 470 μF.
    b. What will be the total charge stored on both of these capacitors after being attached together?
    c. What will be the charge stored on each of these capacitors after being attached together?
    d. What will be the potential difference across each of the these capacitors after being attached together?

ANSWERS TO THE OPPOSITE SIDE:
19a.. 5000 μC, 19,800 μC b. 24,800 μC c. 7750 μC, 17,050 μC d. 7.75 Volts e. 14,800 μC f. 4625 μC,
19f. 10,175 μC g. 4.625 Volts 20a. 3300 μC, 24,750 μC b. 28,050 μC c. 7010 μC, 21,040 μC
20d. 12.75 Volts e. 21,450 μC f. 5360 μC, 16,100 μC g. 9.75 Volts 21a. 2.30 μF b. 27.6 μC c. 166 μJ
21d. 13.8 μF e. 166 μC f. 994 μJ g. 828 μJ 22. 48.0 C

PHYSICS HOMEWORK #148 ELECTROSTATIC POTENTIAL
CAPACITORS CONNECTED TOGETHER

19. A 1000 μF capacitor is charged up by a 5.00 Volt battery while a second capacitor, which has a capacitance of 2200 μF is charged up with a 9.00 Volt battery.
   a. What will be the charge stored on each capacitor after being charged up?
   These capacitors are then attached together, positive to positive, negative to negative.
   b. What will be the total charge stored on these two capacitors after being attached together?
   c. What will be the charge stored on each capacitor after being attached together?
   d. What will be the potential difference across each of the these capacitors after being attached together?
   Suppose instead that these two capacitors had been connected together, positive to negative, positive to negative.
   e. What will be the total charge stored on these two capacitors after being attached together?
   f. What will be the charge stored on each capacitor after being attached together?
   g. What will be the potential difference across each of the these capacitors after being attached together?

20. A C_1 = 550 μF capacitor is charged up by a V_1 = 6.00 Volt battery while a second capacitor, which has a capacitance of C_2 = 1650 μF is charged up with a V_2 = 15.0 Volt battery.
   a. How much charge will be stored on each capacitor after being charged by their respective batteries?
   These two capacitors are then attached together, positive to positive, negative to negative.
   b. What will be the total charge stored on these two capacitors after being attached together?
   c. What will be the charge stored on each capacitor after being attached together?
   d. What will be the potential difference across each of the these capacitors after being attached together?
   Suppose instead that these two capacitors had been connected together, positive to negative, positive to negative.
   e. What will be the total charge stored on these two capacitors after being attached together?
   f. What will be the charge stored on each capacitor after being attached together?
   g. What will be the potential difference across each of the these capacitors after being attached together?

21. A parallel plate capacitor is made up of two plates, each of which has an area of 6.50 m^2, separated by 0.0250 mm of air.
   a. What will be the capacitance of this capacitor?
   b. How much charge will be stored in this capacitor when charged to a potential of 12.0 Volts?
   c. How much energy will be stored in this capacitor when charged up to a potential of 12.0 Volts?
   Suppose that the air between the plates is replaced by mica. [K = 6.0]
   d. What will be the new capacitance of this capacitor?
   e. How much charge will be stored in this capacitor when charged to a potential of 12.0 Volts?
   f. How much energy will be stored in this capacitor when charged up to a potential of 12.0 Volts?
   Suppose that you now attempt to remove the mica from the capacitor.
   g. How much work would be required to remove the mica?

22. A parallel plate capacitor is made of two parallel plates, each with an area A, separated by a distance d and which is filled with air. This capacitor has a capacitance C. Suppose that this capacitor is changed so that the **area** of each plate is **tripled**, the **distance** between the plates is **halved** and the air is replaced with **glass**, which has a dielectric constant of K = 8.00. What is the new capacitance of this capacitor?

Answers to opposite side: 16a. 650 μA b. 8.45 Volts c. 11.5 s d. $I = I_o \bullet e^{-t/tc}$ = 650 μA • $e^{-t/11.5}$
16e. 48.0 μA f. 7475 μC g. 885 μF h. 1300 μC i. 0.40 μA 17a. 0.705 s b. 2820 μC c. 4000 μA
17d. 476 μA e. 3.25 s 18a. 2640 μC b. 2640 μC c. 1800 μC, 840 μC d. 3.82 Volts

PHYSICS HOMEWORK #149 ELECTROSTATIC POTENTIAL
CAPACITORS AND CAPACITIVE REACTANCE

1. Consider a capacitor consisting of two parallel plates, each with an area of 2.35 $meters^2$, separated by a distance of d = 0.0025 millimeters. Initially, this capacitor is uncharged and at t = 0 seconds it is connected in series with a resistance of 450 Ω and a battery which has an EMF of 12.0 Volts.
   a. What is the capacitance of this capacitor?
   b. What will be the initial current flowing through this circuit?
   c. What will be the initial voltage drop across the resistor?
   d. What will be the initial voltage drop across the capacitor?
   e. What will be the current flowing in this circuit a long time after it has been connected?
   f. What will be the voltage drop across the resistor a long time after this circuit has been connected?
   g. What will be the voltage drop across the capacitor a long time after the circuit has been connected?
   h. What is the time constant for this circuit?
   i. Write an equation describing the current flowing through this circuit as a function of time?
   j. What will be the current flowing through this circuit t = 2.00 milliseconds after it has been connected?
   k. How much charge will be stored in this capacitor t = 2.00 milliseconds after it has been connected?
   Suppose now that the V = 12.0 Volt battery is removed and is replaced by an AC power supply of V_p = 170 Volts at a frequency of f = 320 Hz.
   l. What will be the **capacitive reactance** of this circuit?
   m. What will be the **RMS** current flowing through this circuit?
   n. What will be the **phase angle** in this circuit?
   o. What will be the **power factor** in this circuit?
   p. At what rate is **energy** being consumed in this circuit?

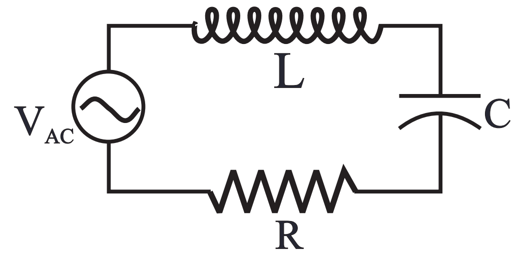
$$X_c = \frac{1}{\omega C}$$
$$Z = \sqrt{R^2 + (X_L - X_c)^2}$$
$$\cos(\phi) = \frac{R}{Z}$$

2. Consider a capacitor consisting of two parallel plates, each with an area of 4.25 $meters^2$, separated by a distance of d = 0.00130 millimeters. Initially, this capacitor is connected in series with a 25,000 Ω resistor and a V = 15.0 Volt DC power supply until the capacitor is fully charged.
   a. What is the capacitance of this capacitor?
   b. What will be the current flowing through this circuit after the capacitor has been fully charged?
   c. What will be the voltage drop across the resistor after the capacitor has been fully charged?
   d. What will be the voltage drop across the capacitor after the capacitor has been fully charged?
   This circuit is then removed from the battery and the two leads are shorted together to form a simple circuit consisting of a capacitor and resistor in series.
   e. What will be the time constant for this circuit?
   f. What will be the current flowing in this circuit immediately after it has been connected?
   g. What will be the voltage drop across the resistor a long time after this circuit has been connected?
   h. What will be the voltage drop across the capacitor a long time after the circuit has been connected?
   i. Write an equation describing the current flowing through this circuit as a function of time?
   j. What will be the current flowing through this circuit 0.3 seconds after this circuit has been connected?
   k. How much charge will remain in this capacitor 0.3 seconds after this circuit has been connected?
   The resistor and capacitor in series are now connected to an AC power supply which has a voltage of V_p = 45.0 Volts at a frequency of f = 1.20 Hz.
   l. What is the capacitive reactance of this capacitor at this frequency?
   m. What will be the impedance of this circuit?
   n. At what rate will energy be dissipated in this circuit?

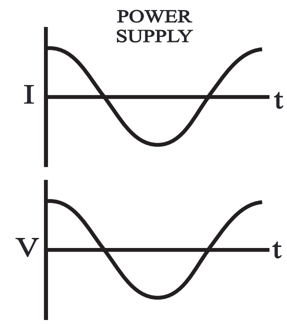
Answers to opposite side: 3a. 44.8 Ω b. 1.51 Ω c. 50.0 Ω d. 31.8 Volts e. 0.900 Amps f. 0.64 Amps 3g. 60.0° h. 50.0 % i. 10.1 Watts k. 80.7 Hz. l. 8.22 Ω m. 8.22 Ω n. 25.0 Ω o. 100 % p. 40.7 Watts

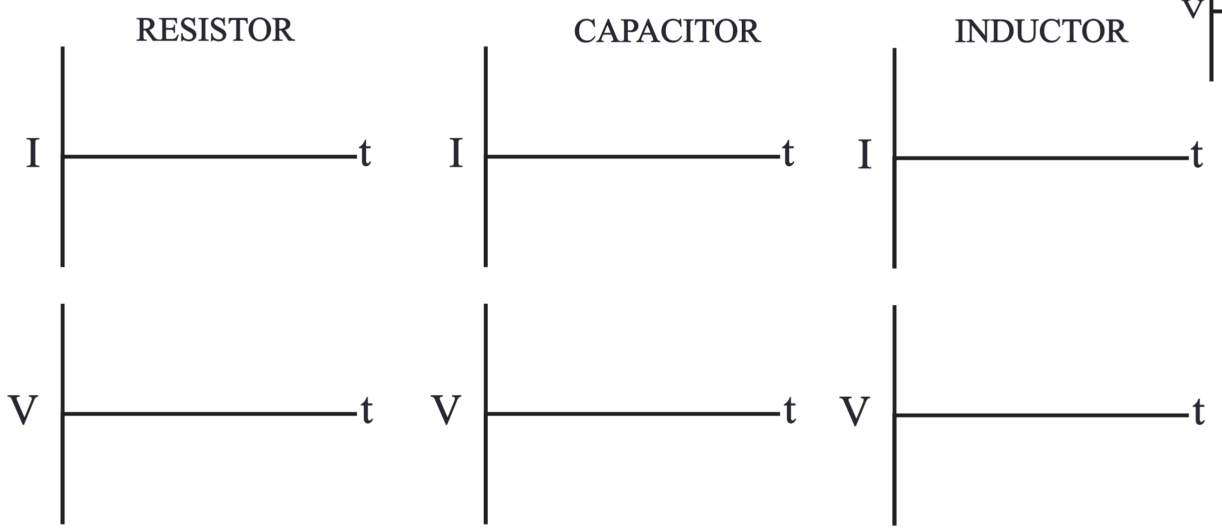
PHYSICS HOMEWORK #150 ELECTROSTATIC POTENTIAL
INDUCTANCE, CAPACITANCE & RESISTANCE

3. Consider an electrical circuit consisting of a resistor R = 25.0 Ω, an inductor L = 16.2 milliHenry, a capacitor C = 240 μFarads and an AC power supply V_P = 45.0 Volts oscillating at a frequency of f = 440 Hz., all connected together in a simple series circuit as shown to the right.



a. What is the **inductive reactance** of this inductor?
b. What is the **capacitive reactance** of this capacitor?
c. What is the **impedance** of this circuit?
d. What is the **RMS voltage** of this power supply?
e. What will be the **peak current** flowing in this circuit?
f. What will be the **RMS current** flowing in this circuit?
g. What will be the **phase angle** of this circuit?
h. What is the **power factor** for this circuit?
i. What is the **average power** being supplied to this circuit?
j. Assuming that the current and voltage being supplied by the power supply are as shown to the right, sketch below the corresponding currents and voltages across the esistor, the inductor and the capacitor.





Assume, now, that the frequency f of the power supply is varied until the circuit reaches resonance.
k. What is the **resonant frequency f_o** of this circuit?
l. What is the **inductive reactance** of this circuit while at resonance?
m. What is the **capacitive reactance** of this circuit while at resonance?
n. What is the **impedance** of this circuit while at resonance?
o. What is the **power factor** of this circuit at resonance?
p. How much **power** is being dissipated by this circuit while at resonance?

Answers to opposite side: 1a. 8.32 μFarads b. 0.027 Amps c. 12.0 Volts d. 0.0 Volts e. 0.0 Amps f. 0.0 Volts 1g. 12.0 Volts h. 3.74 x 10^{-3} s i. I = 0.027 $e^{-t/.00374}$ s j. 0.0158 Amperes k. 4.15 x 10^{-5} Coulombs l. 59.8 Ω 1m. 0.235 Amps n. -7.57° o. 0.99x p. 28.0 Watts 2a. 28.9 μFarads b. 0.0 Amps c. 0.0 Volts d. 15.0 Volts 2e. 0.723 s f. 600 μAmps 2g. 0.0 Volts h. 0.0 Volts i. I = 600 $e^{-t/0.723}$ μAmps j. 396 μAmperes 2k. 286 μCoulombs l. 4590 Ω m. 25400 Ω m. 0.040 Watts