Solution Videos to Physics Problems
Electricity & Magnetism

For video solutions to these problems go to www.foothill.edu/~cascarano/videos.html

ELECTRIC FIELDS & FORCES

EM_03B (from Young and Freedman 12th edition, 21-89) (calculus required) Positive charge Q is distributed uniformly along the x-axis from x = 0 to x = a. A positive point charge q is located on the positive x-axis at x = a+b, a distance b to the right of the end of Q. (a) Calculate the components of the electric field produced by the charge distribution Q along the positive x-axis for x > a. (b) Calculate the force (magnitude and direction) that the charge distribution Q exerts on q. (c) Show that if b >> a, the magnitude of the force in part (b) is approximately $Qq/4\pi\varepsilon_o r^2$. Explain why we get this result.

EM_04B (from Young and Freedman 12th edition, 21-90) (calculus required) Positive charge Q is distributed uniformly along the y-axis from y = 0 to y = a. A negative point charge -q is located on the positive x-axis a distance x from the origin. Calculate the components of the electric field produced by the charge distribution Q along the positive x-axis.

EM_11 Gauss's Law (the solution video has three parts)
In this problem we have three charged objects:

1) A solid, spherical insulator with uniform charge density throughout its volume. It carries a total charge of Q_1, has a radius of a, and is centered at the origin.
2) A conductive, spherical shell concentric with the sphere. It carries a total charge of Q_2, inner radius b and outer radius c.
3) Another conductive, spherical shell concentric with the other two objects. It carries a total charge of Q_3, inner radius d and outer radius e.

Find the electric field everywhere. Find the total charge on each of the four conductive surfaces (inner surface of the smaller shell, outer surface of the smaller shell, inner surface of the large shell, and outer surface of the large shell). Plot the electric field vs distance from the origin if:

$Q_1 = +6\ \mu C$ (yes, you need to know that μ is 10^{-6})
$Q_2 = -10\ \mu C$
$Q_3 = +3\ \mu C$

EM_14B (from Young and Freedman 12th edition, 22-4)
A cube has sides of length L = 0.3 m. It is placed with one corner at the origin and sides along the positive x, positive y, and positive z axes. The electric field is not uniform, but given by $\vec{E} = \left(-5\left(\frac{N}{C}\right)m\right)x\hat{\imath} + \left(3\left(\frac{N}{C}\right)m\right)z\hat{k}$. (a) Find the electric flux through each of the six faces of the cube. (b) Find the total electric charge inside the cube.

EM_16B (from Young and Freedman 12th edition, 22-36)
A long line charge carries a uniform linear charge density +50 $\mu C/m$ runs parallel to and 10 cm from the surface of a large, flat plastic sheet that has a uniform surface charge density of -100 $\mu C/m^2$ on one side. Find the location of all points where an α particle would feel no force due to this arrangement of charged objects.

ELECTRIC POTENTIAL

EM_21 Electric Potential (the solution video has two parts)
In this problem we have three charged particles:

1) A charge, q_1, is located at the origin.
2) A charge, q_2, is located on the y axis at (0, a).
3) A charge, q_3, is located on the x axis at (a, 0).

Find the work done by an external force in moving charge q_3 from (a, 0) to (a, a) if:

$q_1 = +4\mu C$	$q_3 = +3\ \mu C$
$q_2 = -2\ \mu C$	a = 2 m

EM_23B (from Young and Freedman 12th edition, 23-70)
A thin insulating rod is bent into a semicircular arc of radius a, and a total electric charge Q distributed along the rod. Calculate the potential at the center of curvature of the arc if the potential is assumed to be zero at infinity.

EM_24B (from Young and Freedman 12th edition, 23-74)
An insulating spherical shell with inner radius 25 cm and outer radius 60 cm carries a charge of +150 μC uniformly distributed over its outer surface. Point a is at the center of the shell, point b is on the inner surface, and point c is on the outer surface. (a) What will a voltmeter read if connected between the following points: (i) a and b; (ii) b and c; (iii) c and infinity; (iv) a and c? (b) Which is at higher potential: (i) a or b; (ii) b or c; (iii) a or c? (c) Which, if any, of the answers would change sign if the charge was -150 μC?

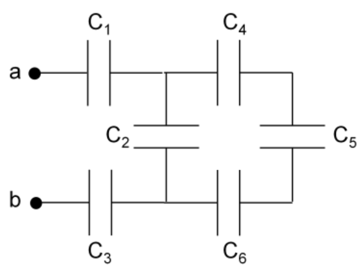
EM_25B (from Young and Freedman 12th edition, 23-83)
A metal sphere with radius R_1 has a charge Q_1. Take the electric potential to be zero at an infinite distance from the

sphere. (a) What are the electric potential and electric field at the surface of the sphere? This sphere is now connected by a long, thin conducting wire to another sphere of radius R_2 that is several meters from the first sphere. Before the connection is made, this second sphere is uncharged. After electrostatic equilibrium has been reached, what are (b) the total charge on each sphere; (c) the electric potential at the surface of each sphere; (d) the electric field at the surface of each sphere? Assume the amount of charge on the wire is small compared to the charge on the spheres.

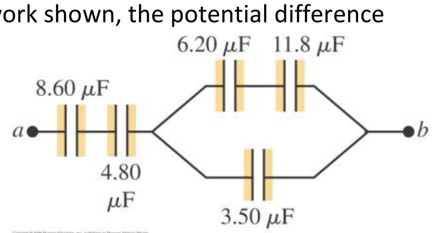
CAPACITORS

EM_31 Capacitors (the solution video has two parts)
Find the charge on each capacitor and the potential difference across each capacitor in the following circuit:

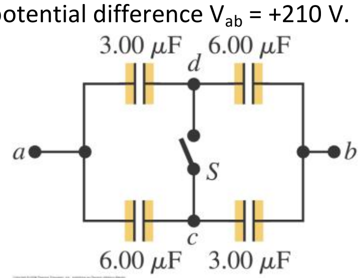
Given:
$C_1 = C_2 = C_3 =$
$C_4 = C_5 = C_6 = 3\ \mu F$
$\Delta V_{ab} = 110$ V



EM_32C (from Young and Freedman 12th edition, 24-57)
For the capacitor network shown, the potential difference across ab is 12 V. Find (a) the total energy stored in this network and (b) the energy stored in the 4.8 μF capacitor.



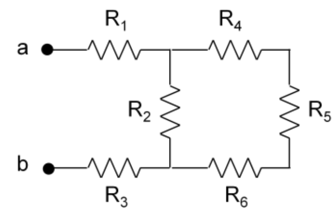
EM_33C (from Young and Freedman 12th edition, 24-60)
The capacitors in the figure are initially uncharged and the switch is open. The applied potential difference $V_{ab} = +210$ V. (a) What is the potential difference V_{cd}? What is the potential difference across each capacitor after switch S is closed? (c) How much charge flowed through the switch when it was closed?



RESISTORS

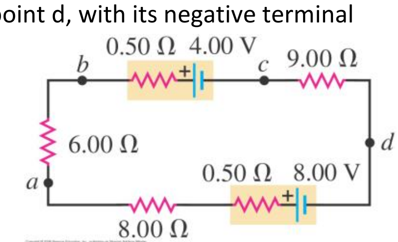
EM_36 Resistors
Find the current through each resistor and the potential difference across each resistor in the following circuit:

Given:
$R_1 = R_2 =$
$R_3 = R_4 =$
$R_5 = R_6 = 4\ \Omega$
$\Delta V_{ab} = 110$V



EM_37C (from Young and Freedman 12th edition, 25-55)
A 540 W electric heater is designed to operate from 120 V lines. (a) What is its resistance? (b) What current does it draw? (c) If the line voltage drops to 110 V, what power does the heater take? (Assume the resistance is constant. Actually, it will change because of the change in temperature.) (d) The heater coils are metallic, so that the resistance of the heater decreases with decreasing temperature. If the change of resistance with temperature is taken into account, will the power consumed by the heater be larger or smaller than what you calculated in part (c)?

EM_38C (from Young and Freedman 12th edition, 25-68)
(a) What is the potential difference V_{ad} in the circuit shown? (b) What is the terminal voltage of the 4 V battery? (c) A battery with emf 10.3 V and internal resistance 0.5 Ω is inserted in the circuit at point d, with its negative terminal connected to the negative terminal of the 8 V battery. What is the difference of potential V_{bc} between the terminals of the 4 V battery now?



FOOTHILL COLLEGE PHYSICS

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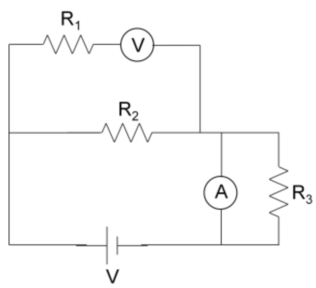
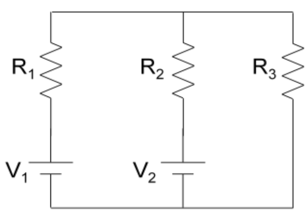
DC CIRCUITS

EM_41 DC Circuits
What are the readings on the ideal ammeter and voltmeter in the following circuit:



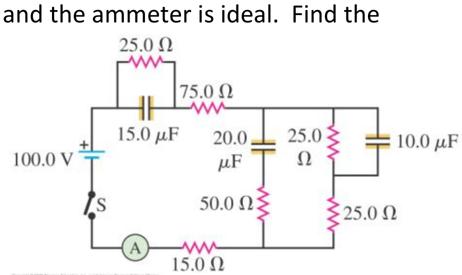
Given:
$R_1 = 1\ \Omega$
$R_2 = 2\ \Omega$
$R_3 = 3\ \Omega$
$\Delta V = 12$ V

EM_42 DC Circuits (the solution video has two parts)
Determine the current in each branch of the following circuit:

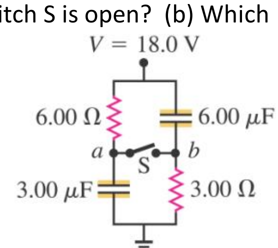


Given:
$R_1 = 1\ \Omega$
$R_2 = 2\ \Omega$
$R_3 = 3\ \Omega$
$\Delta V_1 = 10$ V
$\Delta V_2 = 20$ V

EM_43C (from Young and Freedman 12th edition, 26-47) (the solution video has two parts) In the circuit shown, the capacitors are all initially uncharged, the battery has no internal resistance, and the ammeter is ideal. Find the reading on the ammeter (a) just after the switch S is closed and (b) after the switch has been closed for a very long time.



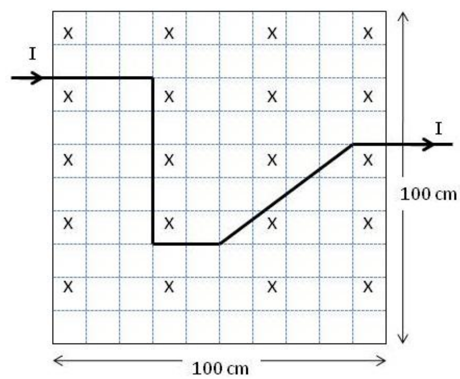
EM_44C (from Young and Freedman 12th edition, 26-74)
In the following circuit: (a) What is the potential of point a with respect to point b when the switch S is open? (b) Which point, a or b, is at the higher potential? (c) What is the final potential of point b with respect to ground when switch S is closed? (d) How much does the charge on each capacitor change when switch S is closed?



MAGNETIC FIELDS & FORCES

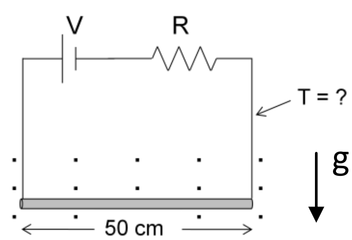
EM_51 Magnetic Forces
A magnetic field, B, is perpendicular to the page and confined within the square region shown. A bent wire lies in the plane of the page, passes through the square region, and carries a current I. Determine the force on the wire.

Given:
I = 5 A
B = 2.5 T

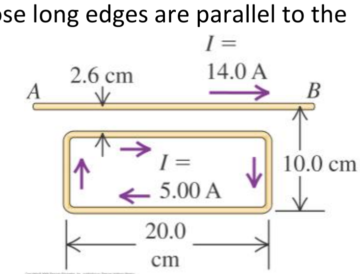


EM_52 Magnetic Forces
A battery and a resistor form a horizontal support for two wires that hang vertically downward. The wires support a rod which has negligible resistance. A magnetic field, B, is perpendicular to the page, as shown. Determine the tension in one of the wires.

Given:
V = 30 V
R = 2 Ω
m = 4 kg (mass of the rod)



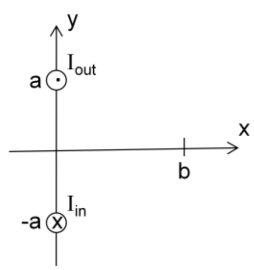
EM_53C (from Young and Freedman 12th edition, 28-64)
The long, straight wire shown below carries a current 14 A. The rectangular loop, whose long edges are parallel to the wire, carries a current of 5 A. Find the magnitude and direction of the net force exerted on the loop due to its interaction with the wire.



EM_56 Magnetic Fields

Two long wires are perpendicular to the page at y = a and y = -a, as shown. Determine the magnetic field on the x-axis at x = b.

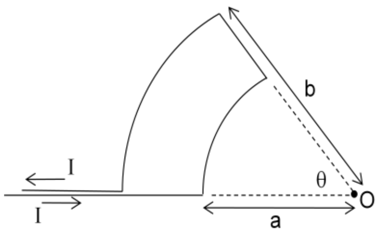
Given:
a = 3 m
b = 4 m
$I_{in} = I_{out} = 10$ A



EM_57 Magnetic Fields

A long wire comes radially inward toward point O, follows a circular arc of radius a , goes radially outward, follows another circular arc of radius b, and goes radially outward (passing very close to the incoming wire). It carries a current I. Determine the magnetic field at the point O.

Given:
Find B in terms of a, b, I, and θ



FARADAY'S LAW & INDUCTION

EM_66 Faraday's Law

A rectangular loop of wire and a long current carrying wire lie in the plane of the page, as shown. The current in the long wire, I_1, varies in time. Determine the current (magnitude and direction) in the loop, I_2, at t = 2 seconds.

Given:
$I_1 = 2t^2+8$
a = 2 m
w = 1 m
L = 3 m
t = 2 s
R = 0.05 Ω (resistance of the wire loop)