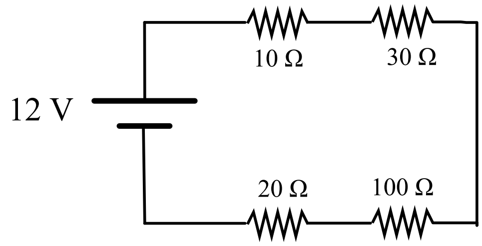
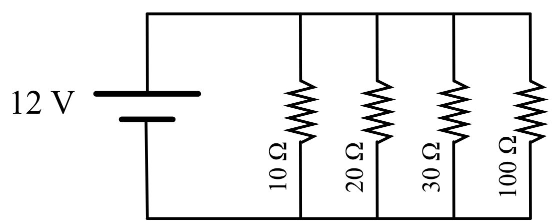
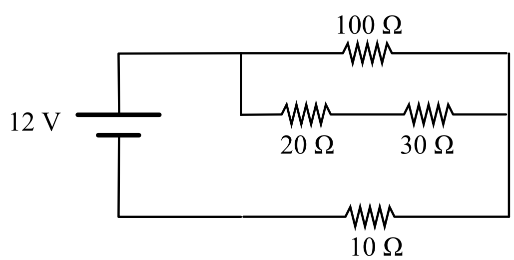
1. A student is provided with a fresh 12.0 V battery and four resistors with the following resistances: 100 Ω, 30 Ω, 20 Ω, and 10 Ω. The student has plenty of good copper wire to hook up circuits with these components.

   (a) Using all of these components, sketch a circuit diagram in which each resistor has a nonzero current flowing through it, but in which the current from the battery is as small as possible.



   (b) Using all of these components, sketch a circuit diagram in which each resistor has a nonzero current flowing through it, but in which the current from the battery is as big as possible (without short circuiting the battery).





The battery and resistors are now hooked up as shown above.

   (c) Find the current flowing through the 10 Ω resistor.

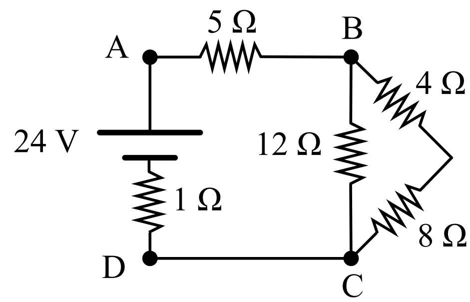
   0.28 A

   (d) Find the total power consumption of the circuit.

   3.3 W

   (e) If the battery stays fresh, how long will it take to provide a total of 10 kJ of electrical energy to the circuit?

   3000 s



2. A 24 V battery with an internal resistance of 1 Ω is connected to a circuit as shown above. Determine the following:

   (a) the equivalent resistance of the 4 Ω, the 8 Ω, and the 12 Ω resistor combination

   6Ω

   (b) the current through the 5 Ω resistor

   2 A

   (c) the voltage between the terminals, V_{AB}

   10 V

   (d) the rate at which energy is dissipated in the 12 Ω resistor

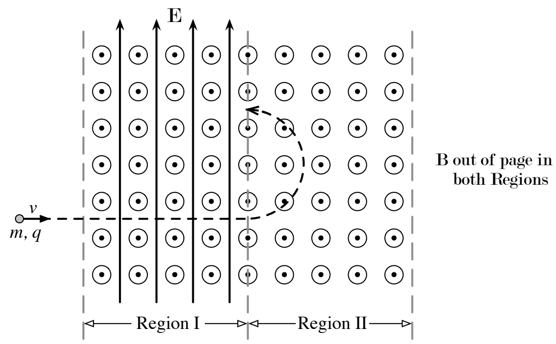
   12 W

   (e) the potential difference V_{BC}

   12 V

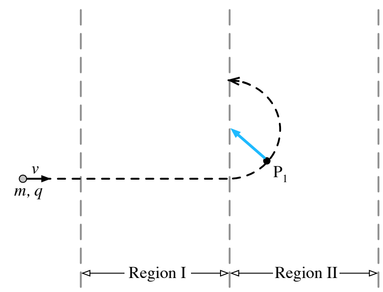
   (f) the power delivered from the battery to the external circuit

   46 W = 48 W from emf - 2 W due to energy lost in 1 Ω internal resistance



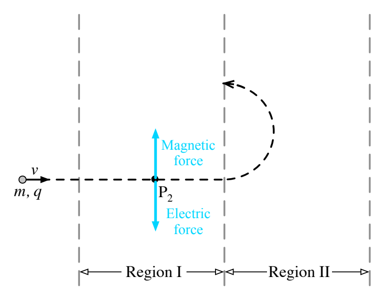
3. An ion of mass m and charge of known magnitude q is observed to move in a straight line through a region of space in which a uniform magnetic field **B** points out of the paper and a uniform electric field **E** points toward the top edge of the paper, as shown in Region I above. The particle travels into Region II in which the same magnetic field is present, but there is no electric field. In Region II the ion moves in a circular path of radius r as shown.

   (a) Indicate on the diagram below the direction of the force exerted on the ion at point P_1 in Region II.



   (b) Is the ion **positively** or **negatively** charged? (Circle one.)

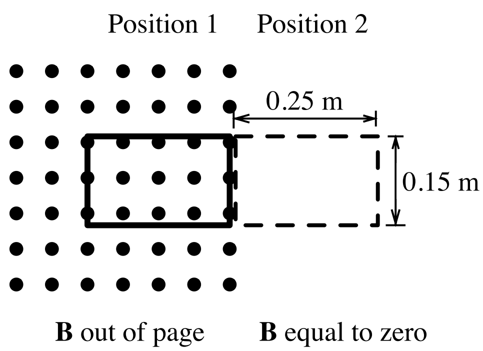
   (c) Indicate and label clearly on the diagram below the forces which act on the ion at point P_2 in Region I.



   (d) Find expressions for the ion's speed v at point P_2 and the radius of its path in Region II in terms of m, q, **E** and **B**.

   In Region I: $q\mathbb{E} = qvB$ while in Region II: $qvB = \dfrac{mv^2}{r}$

   $v = \dfrac{\mathbb{E}}{B}$ ________ $r = \dfrac{m\mathbb{E}}{qB^2}$ ________



4. A 20-turn nichrome wire coil in the shape of a rectangle, 0.25 m by 0.15 m, has a resistance of 5.0 Ω. In Position 1 shown above, the loop is within a uniform magnetic field of strength $B = 0.20$ T. The field is directed out of the page, perpendicular to the plane of the loop. The loop is pulled to the right at a constant velocity, reaching Position 2 in 0.50 s, where $B = 0$.

   (a) Calculate the average emf induced in the 20-turn coil during this period of time.

   $emf = N\Delta\Phi/\Delta t = N\Delta BA/\Delta t = (20)(0.2)(0.15)(0.25)/0.5 = 0.3$ V

   (b) Calculate the magnitude of the current induced in the 20-turn coil, and state whether the current flows in a clockwise direction or a counterclockwise direction.
   $V = iR$ or $i = V/R = 0.3/5 = 0.06$ A

   (c) Calculate the power dissipated in the 20-turn coil.
   $P = iV = (0.06)(0.3) = 0.018$ W

   (d) Calculate the average force necessary to remove the 20-turn coil from the magnetic field as described.
   Each of the 20 wire segments on the left side of the loop feels $F = ilB\sin\theta = (0.06)(0.15)(0.20) = 0.0018$ N. So all 20 turns feel 20×0.009 N $= 0.18$ N The top and bottom sides feel equal and opposite forces, which therefore cancel each other out.

   (e) Identical wire is used to add 20 more turns to the original coil. How does this affect the induced current in the coil under the same conditions? Justify your answer. It leaves the current unchanged. Twice the emf and twice the resistance. Don't worry about this kind of query, though.

5. A wire loop, 2 meters by 4 meters, of negligible resistance is in the plane of the page with its left end in a uniform 0.5 tesla magnetic field directed into the age, as shown above. A 5 ohm resistor is connected between points X and Y. The field is zero outside the region enclosed by the dashed lines. The loop is being pulled to the left end of the loop is still in the field, and points X and Y are not in the field.

   (a) Determine the potential difference induced between points X and Y.

   Use Faraday's Law in the form $\mathcal{E} = Blv$.
   3 V ______________________

   (b) On the figure above show the direction of the current induced in the resistor.

   Use Lenz's Rule: Decreasing flux into the page from the external field results in induced flux into the page.
   Clockwise ______________________

   (c) Determine the force required to keep the loop moving at 3 meters per second.

$V = iR$ where emf $= V$ tells us $i = 0.6$ Amp. $F = ilB = 0.6$ N.

(d) Determine the rate at which work must be done to keep the loop moving at 3 meters per second.

$P = F\Delta x/\Delta t = Fv = 1.8$ W or $P = i^2R = (0.6)^2 \times 5\Omega = 1.8$ W
