Physics 102H Final Exam
May 9 2024

Name (please print): ________________________

This test is administered under the rules and regulations of the honor system of the College of William & Mary.

Signature: _________________________________

Final score: ____________

Some useful constants

$k = 1.38 \times 10^{-23}$ J/K $N_A = 6.022 \times 10^{23}$ $R = kN_A = 8.315$ J/mol · K $0^oC=273K$

one atmosphere = 760 mm Hg = 10^5 Pa 1 cal = 4.186 J 1amu = 1.66×10^{-27}kg

$e=1.6\cdot 10^{-19}$ C $\varepsilon_0=8.84\cdot 10^{-12}$ C^2/Nm^2 $k=9\cdot 10^9$ Nm^2/C^2 $k = \dfrac{1}{4\pi\varepsilon_0}$

$\mu_0=4\pi\cdot 10^{-7}$ H/m $c=3\cdot 10^8$ m/s

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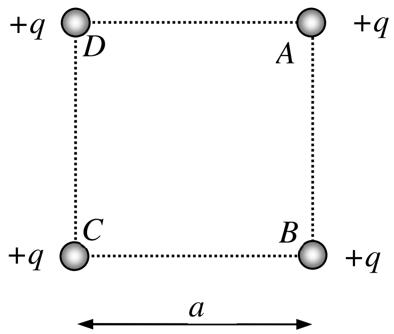

a) Determine the magnitude and direction of the electric field at the center of the square.

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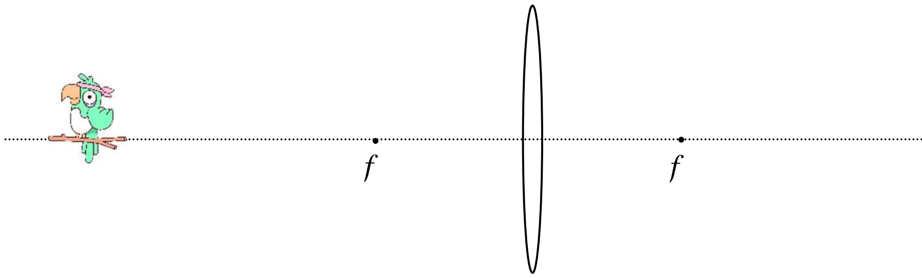

a) Calculate where the image is located with respect to the lens. Use principal ray diagram to verify your answer

b) What is the magnification of the image? Is it real or virtual? Is it upright or inverted?

c) If the bird flies away from the lens at a speed of v_0=40 cm/s, how fast does the image move? Does the image move toward or away from the lens?

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a) If the rod is completely immersed into the liquid helium, what mass of He boils off by the time the rod cools to 4.2 K?

b) The mass density of helium gas at room temperature (297K) is 0.178 kg/m^3. What volume the evaporated gas occupies when it is still at 4.2K, at one atmosphere pressure?

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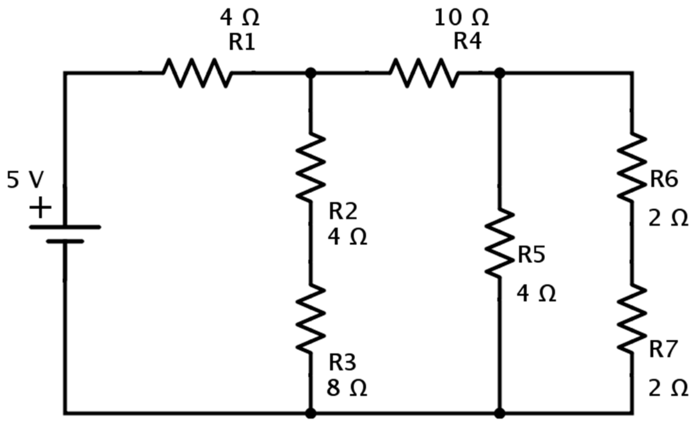

a) What is the equivalent resistance of the circuit?

b) What is the current through the battery?

c) What is the total power dissipated by the circuit?

d) What is the potential difference across the resistor R2?

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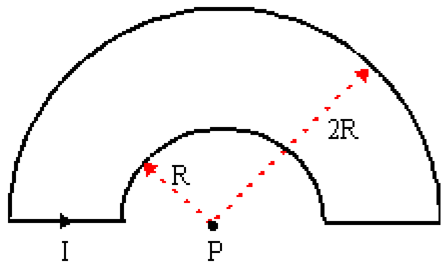
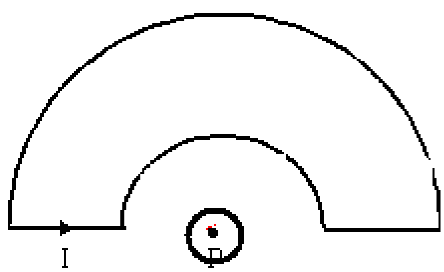


b) A small loop of wire with area A=0.1mm^2 is placed in point P, as shown. If the current I is quickly decreased at a rate dI/dt = -0.25A/s, in what direction the current will flow in the small loop? Explain. What is the magnitude of the current, if the internal resistance of the loop is 10Ω.



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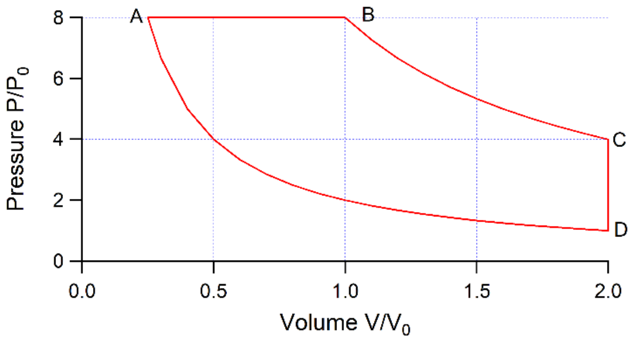

a) Calculate the change in the gas internal energy ΔE_{int}, the work done by the gas W and the heat Q added to the system during each process (in the units of P_0V_0):

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b) Using data from a), calculate the efficiency of this engine.

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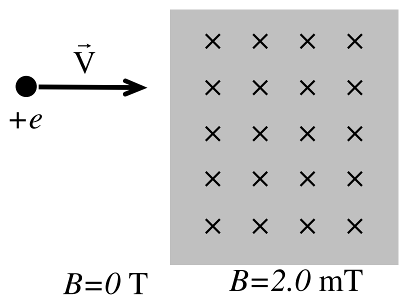

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b) Assuming the maximum depth of penetration into the field is $R=2.0$ cm, find the velocity of the positron.

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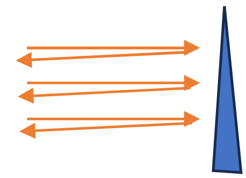

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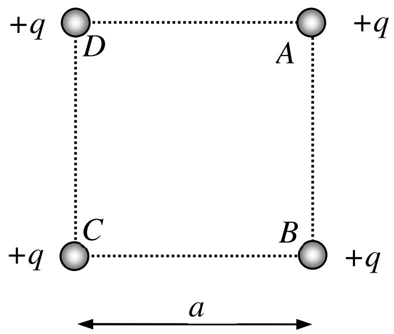

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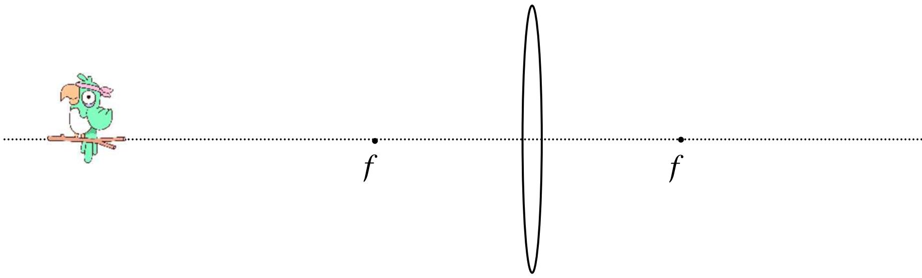

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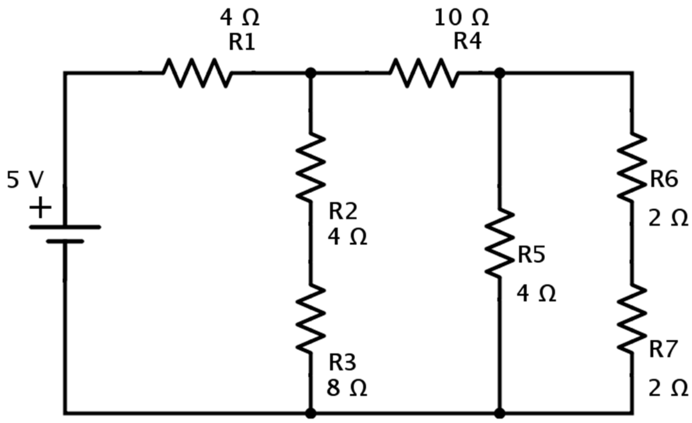

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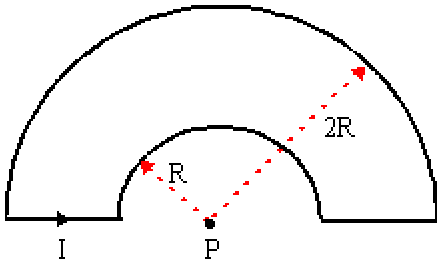

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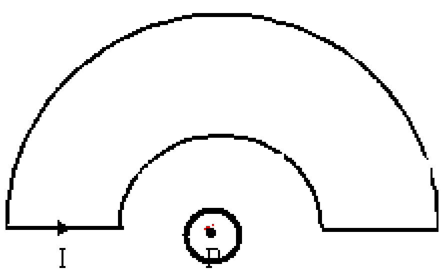

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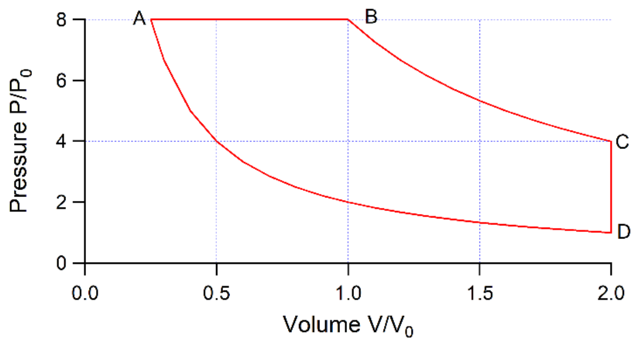

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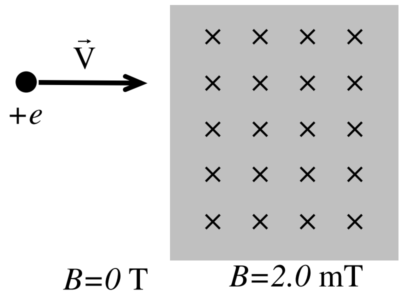

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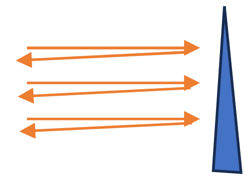

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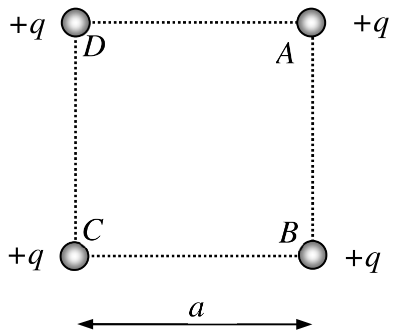

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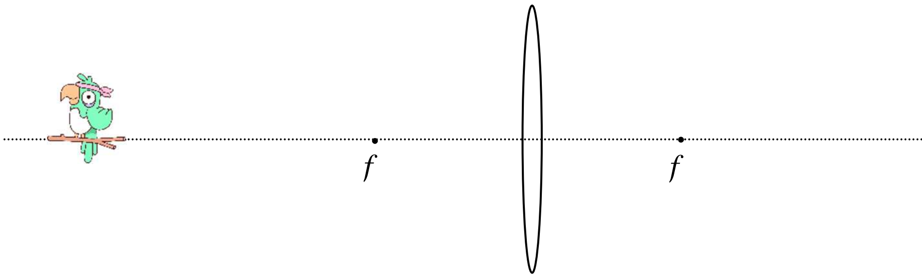

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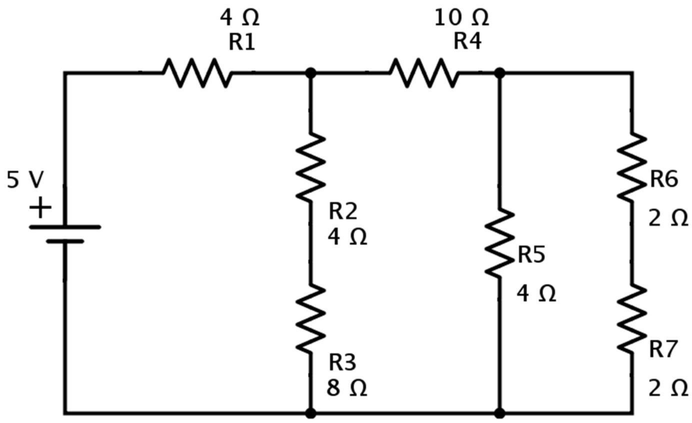

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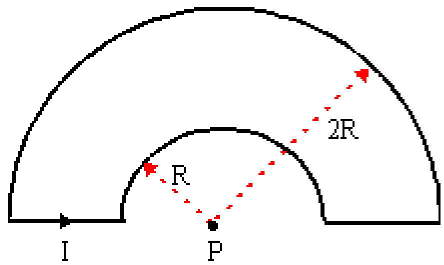

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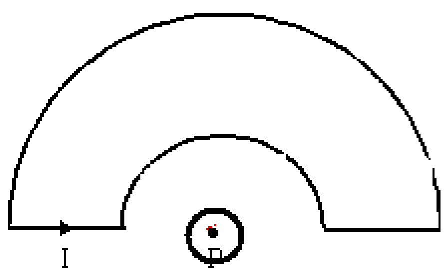

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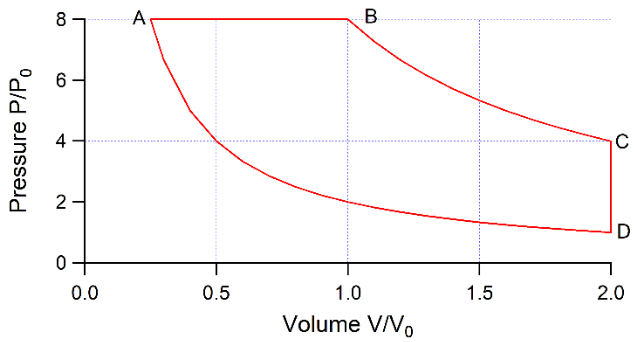

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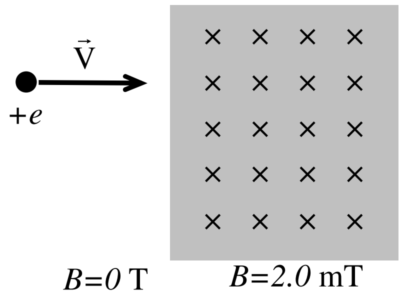

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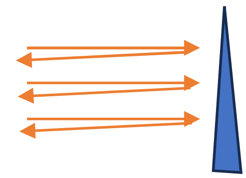

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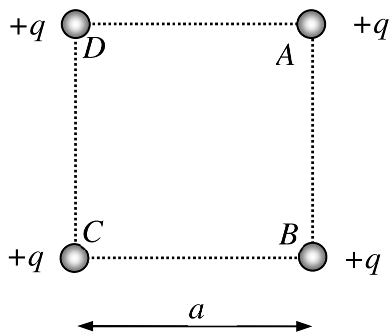

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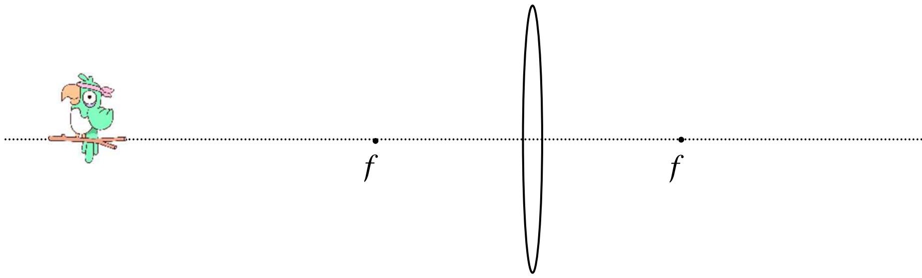

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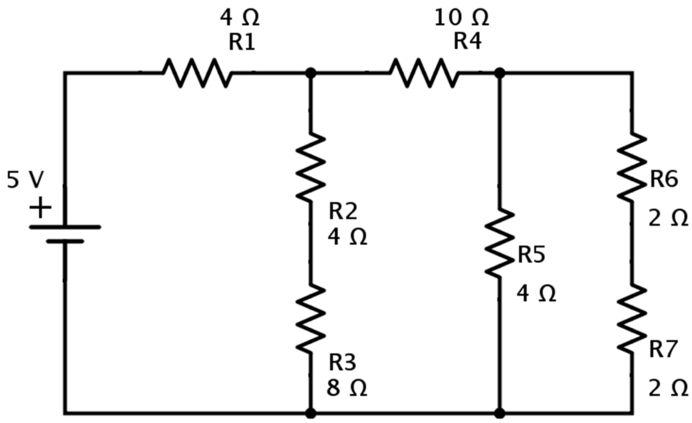

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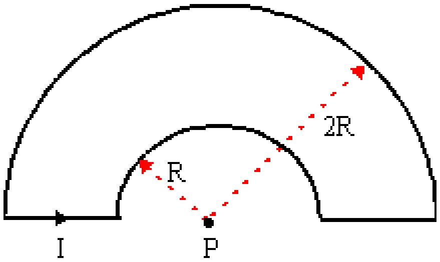

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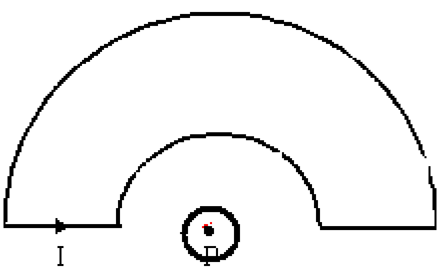

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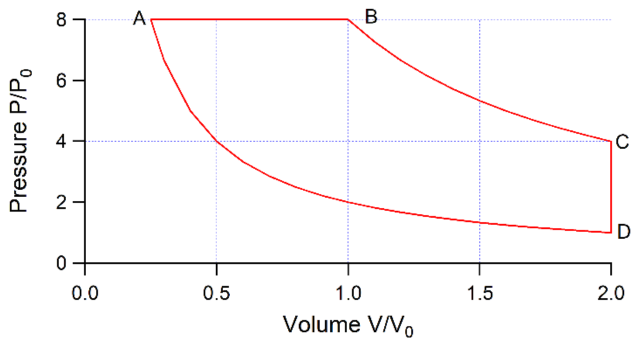

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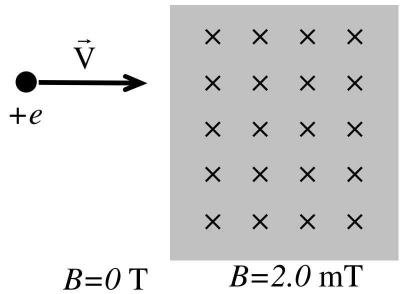

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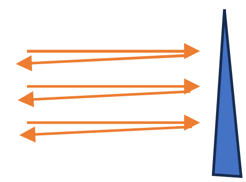

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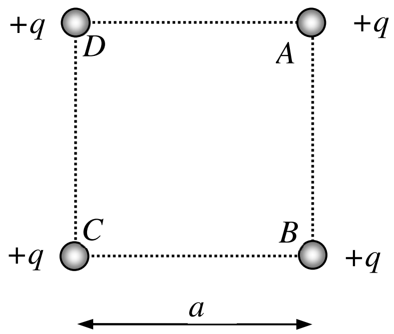

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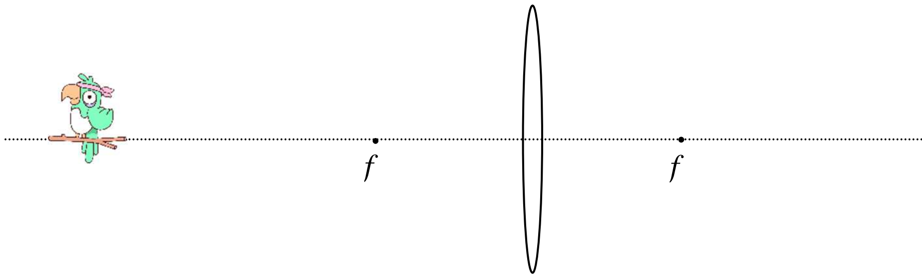

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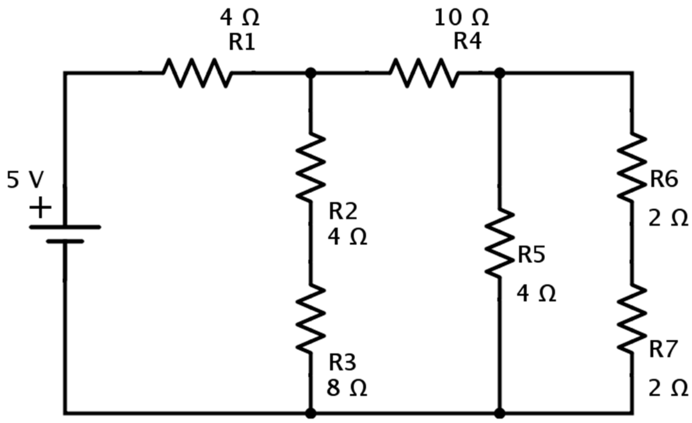

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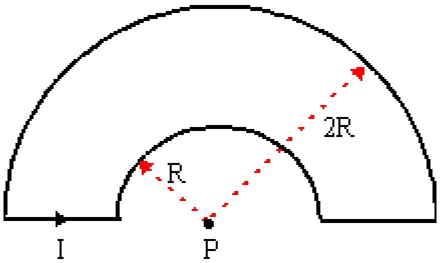

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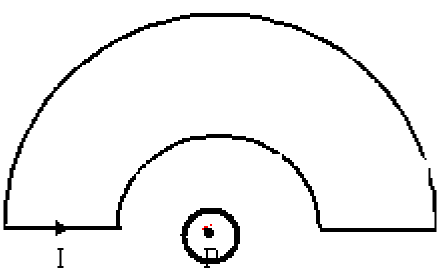

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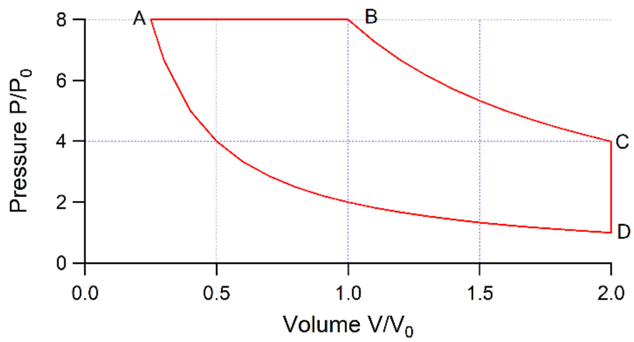

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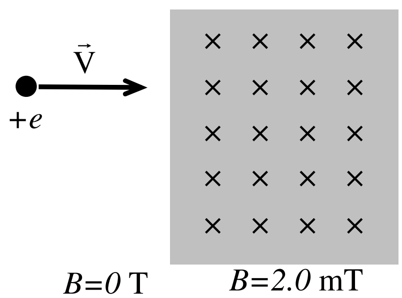

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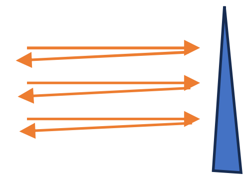

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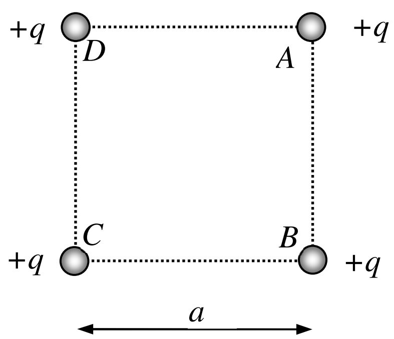

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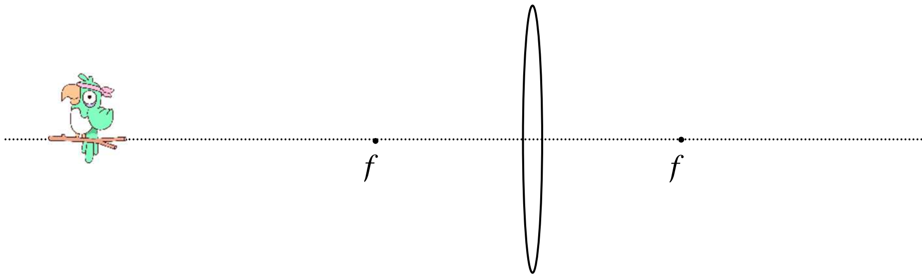

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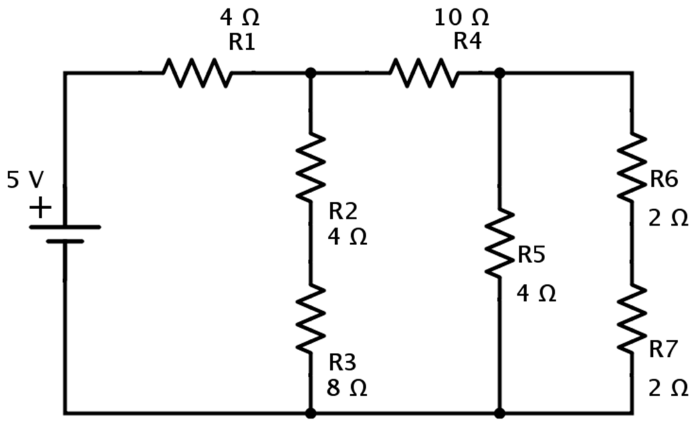

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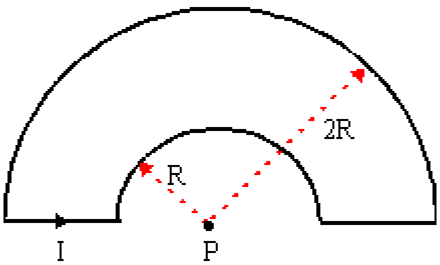

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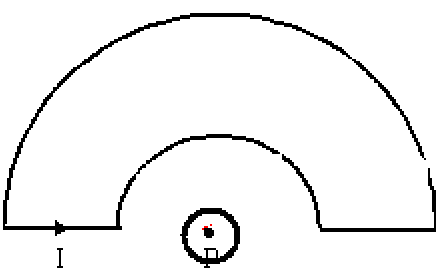

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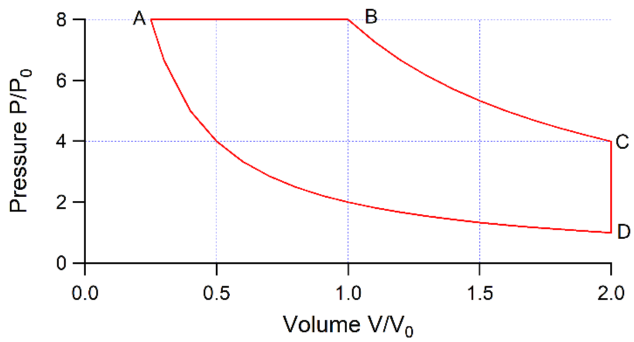

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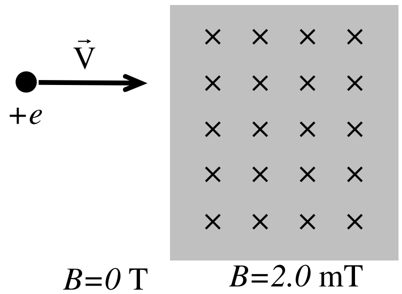

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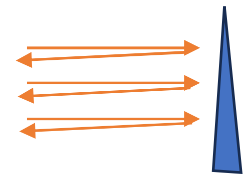

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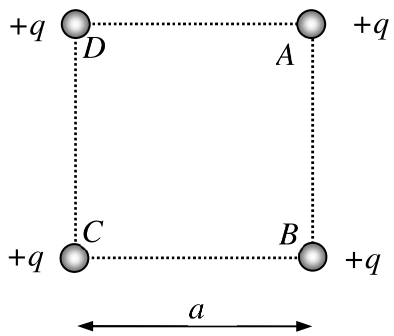

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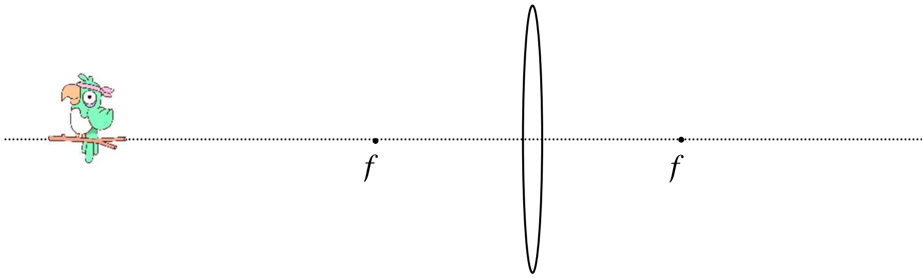

a) Calculate where the image is located with respect to the lens. Use principal ray diagram to verify your answer

b) What is the magnification of the image? Is it real or virtual? Is it upright or inverted?

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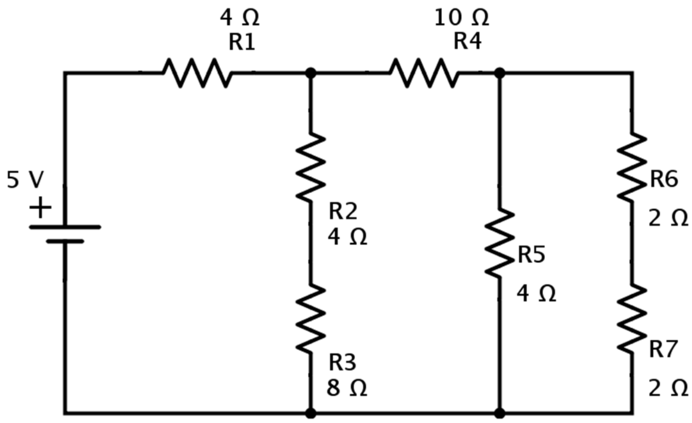

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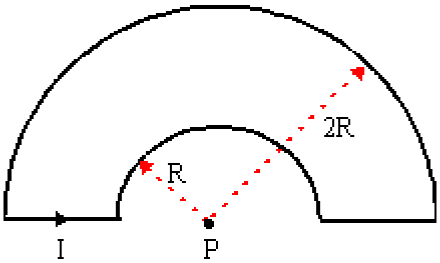

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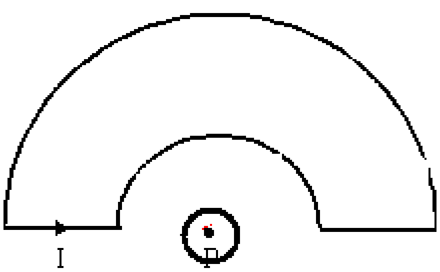

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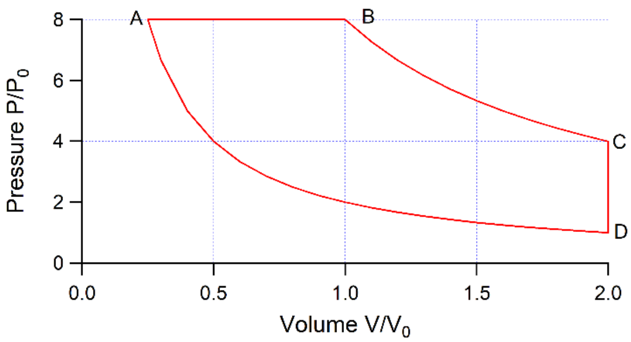

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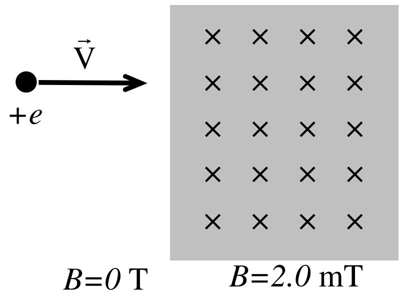

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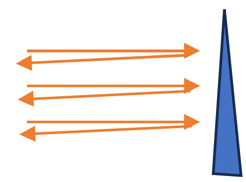

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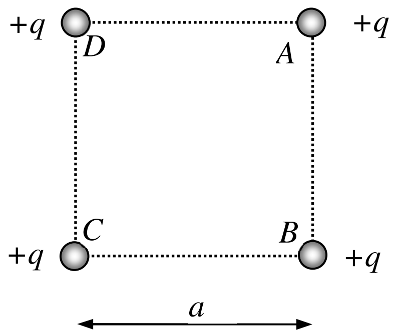

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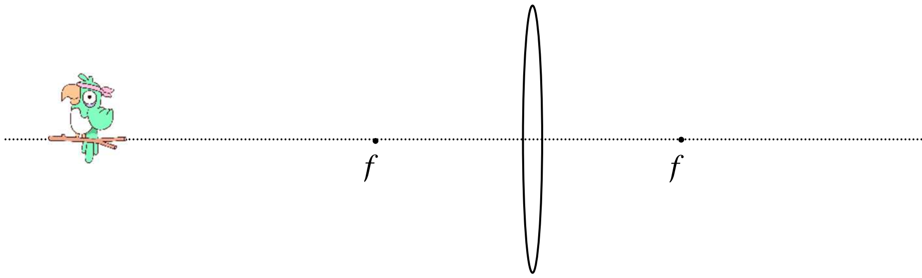

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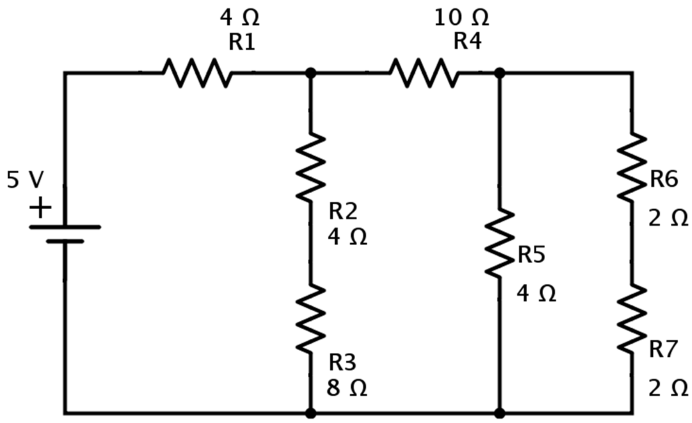

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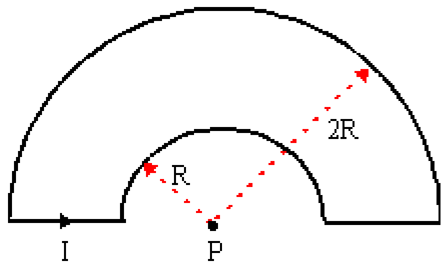

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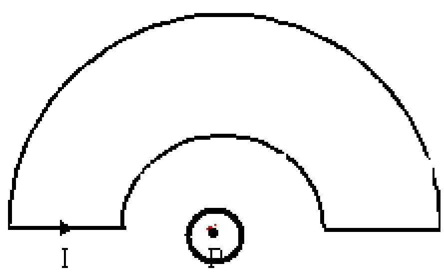

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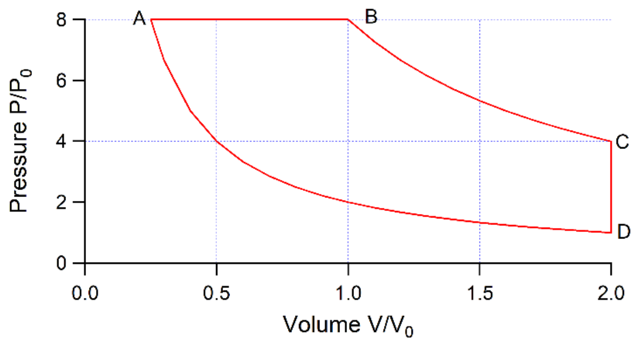

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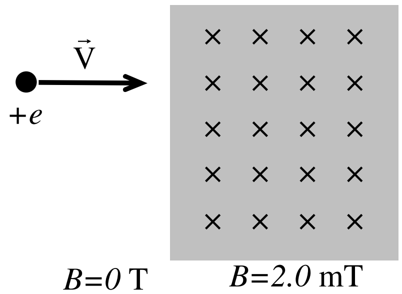

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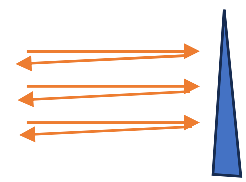

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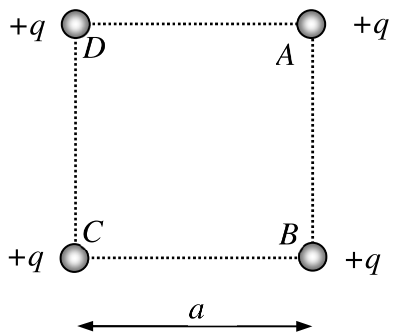

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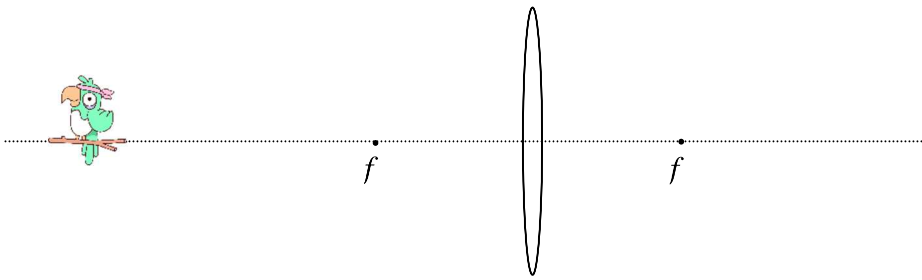

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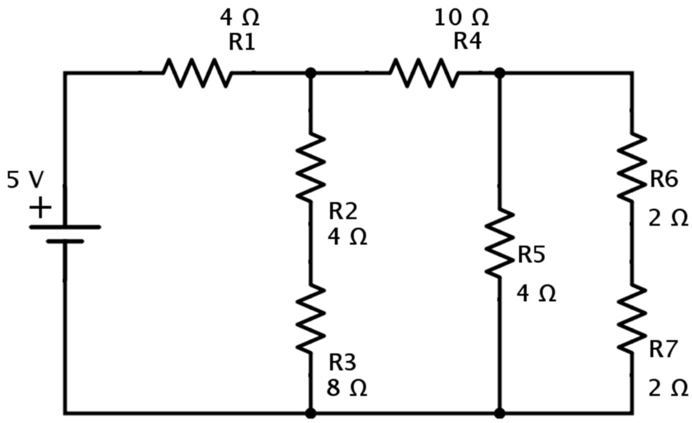

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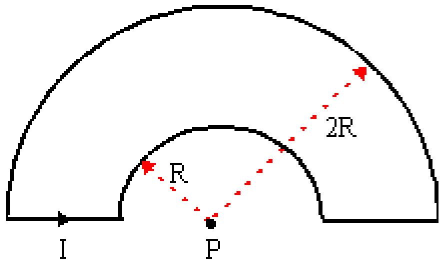
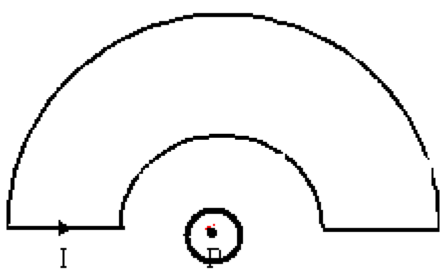


b) A small loop of wire with area A=0.1mm^2 is placed in point P, as shown. If the current I is quickly decreased at a rate dI/dt = -0.25A/s, in what direction the current will flow in the small loop? Explain. What is the magnitude of the current, if the internal resistance of the loop is 10Ω.



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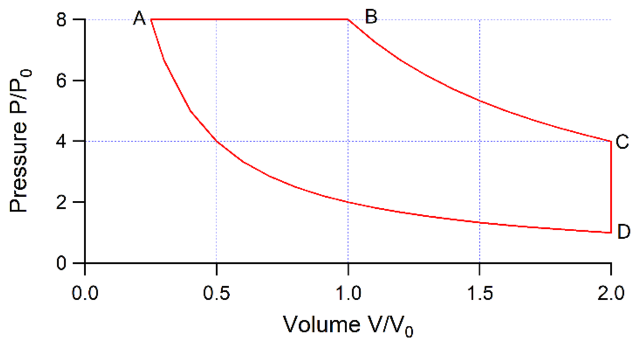

a) Calculate the change in the gas internal energy ΔE_{int}, the work done by the gas W and the heat Q added to the system during each process (in the units of P_0V_0):

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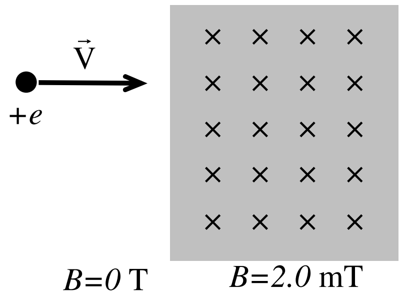

a) Determine the time interval required for the positron to leave the "field-filled" region, noting that the positron's path is a semicircle.

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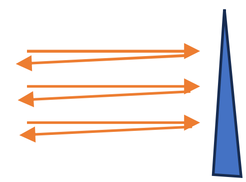

a) Will the top portion of the film appear dark or bright? Explain your answer.

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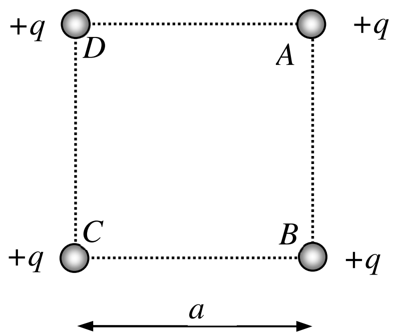

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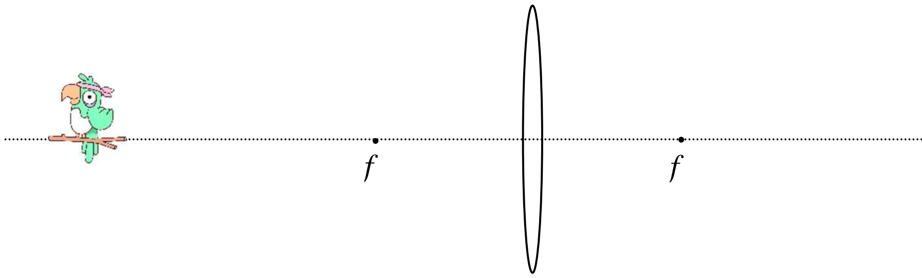

a) Calculate where the image is located with respect to the lens. Use principal ray diagram to verify your answer

b) What is the magnification of the image? Is it real or virtual? Is it upright or inverted?

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An aluminum rod L=0.5 m in length and with a cross-sectional area of A=2.5 cm^2 is inserted into a thermally insulated vessel containing liquid helium at T_{He} = 4.2 K. The rod is initially at T_0=300K. *Some possibly useful properties: boiling point for He = 4.2K, latent heat of evaporation for He = 2.1×10^4 J/kg, specific heat of He = 5200 J/kg·K, specific heat of aluminum = 897 J/kg·K , mass density of aluminum 2800 kg/m^3.*

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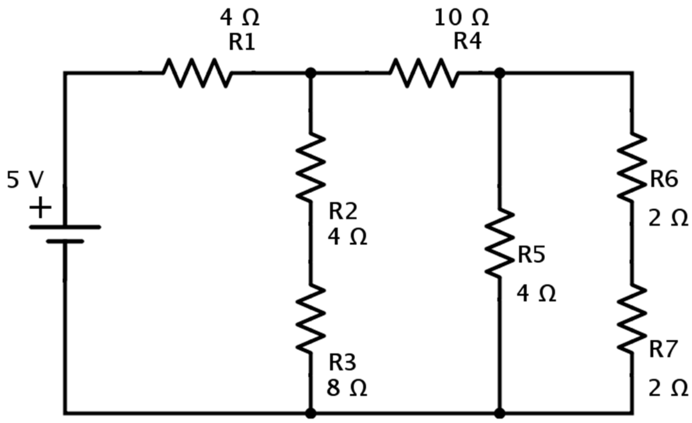

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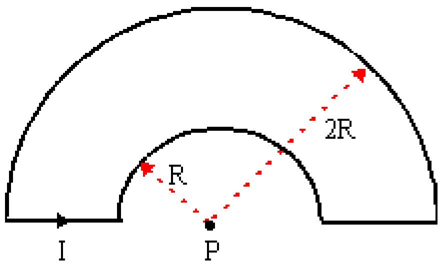

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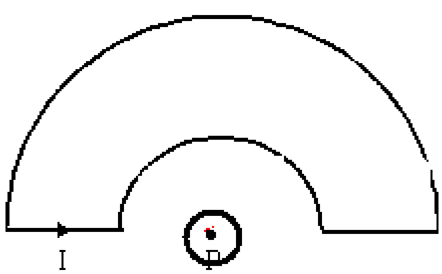

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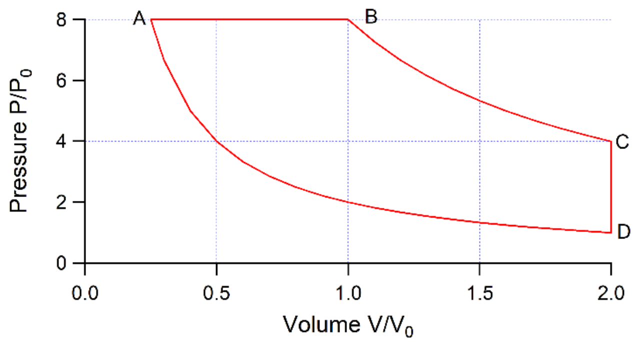

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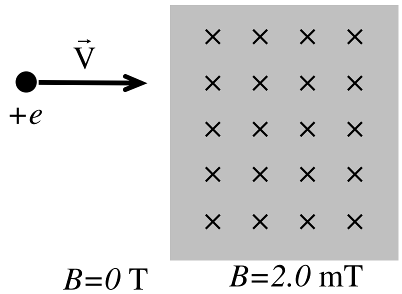

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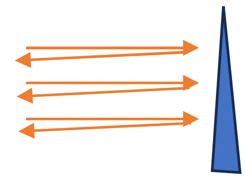

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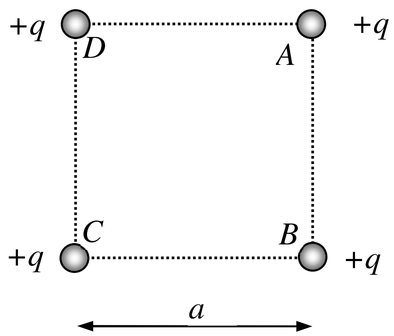

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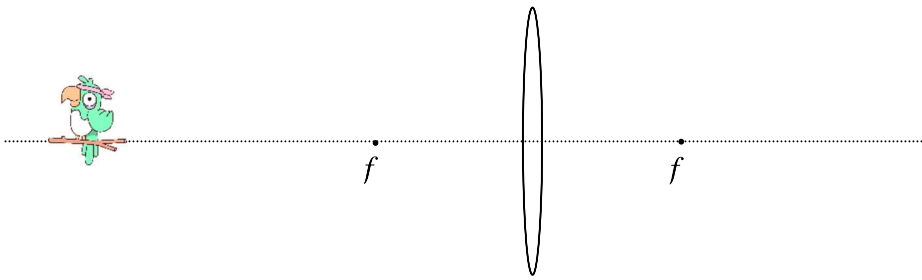

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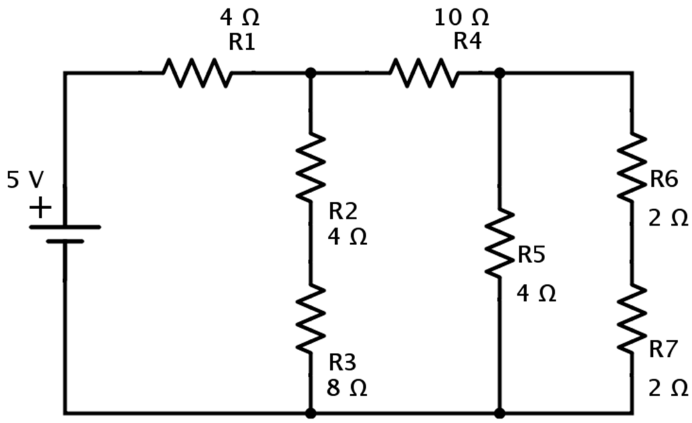

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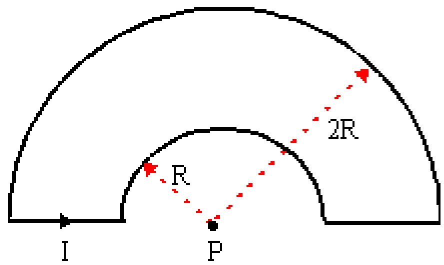

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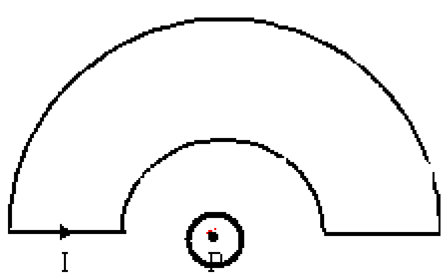

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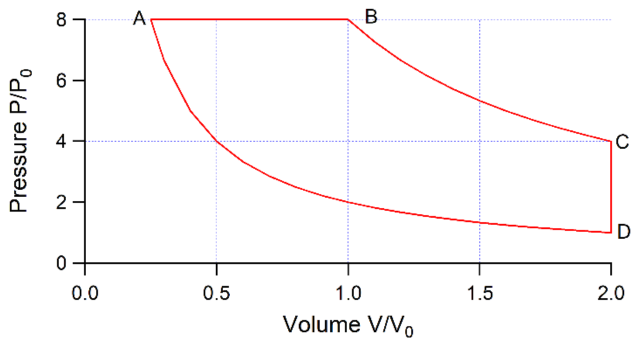

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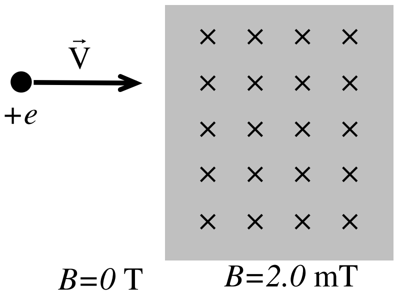

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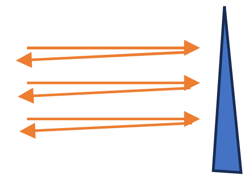

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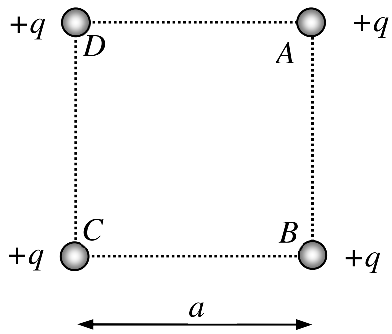

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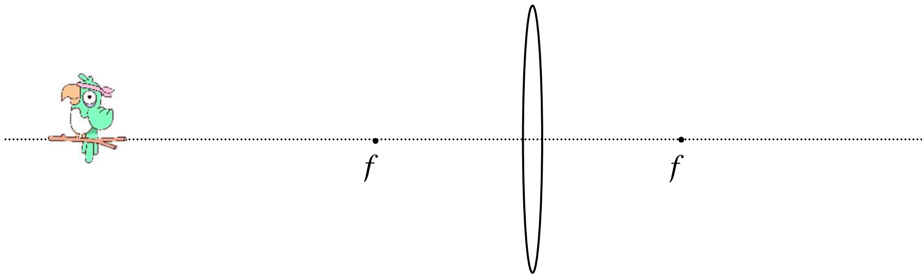

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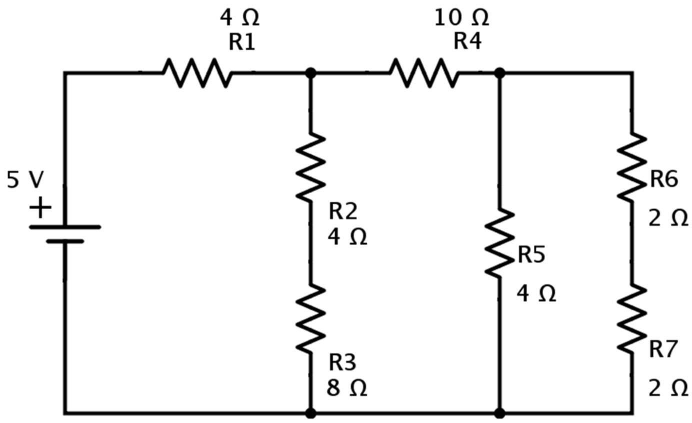

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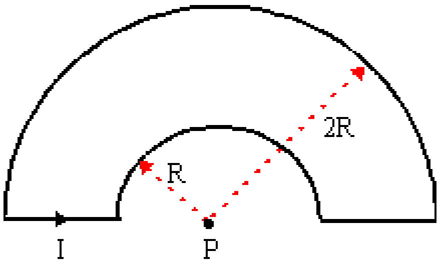

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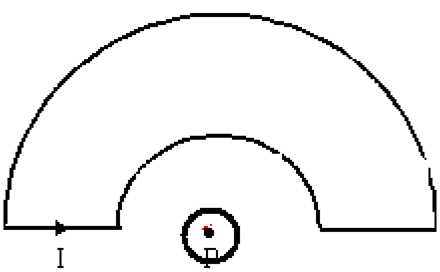

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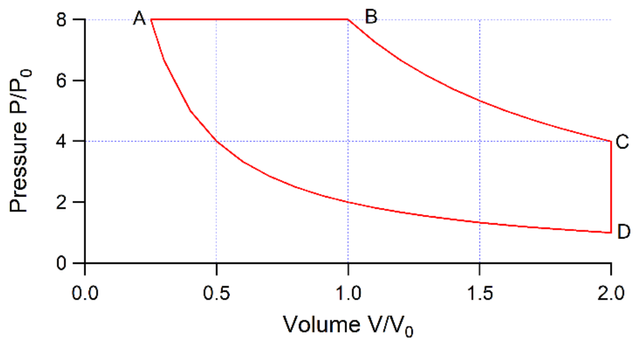

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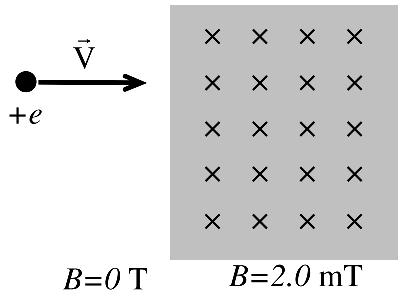

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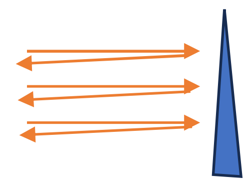

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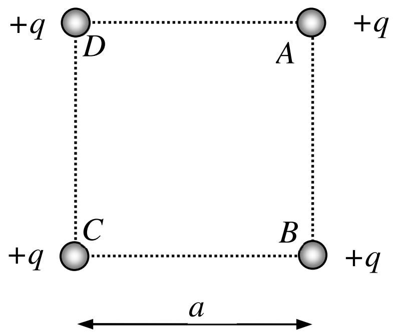

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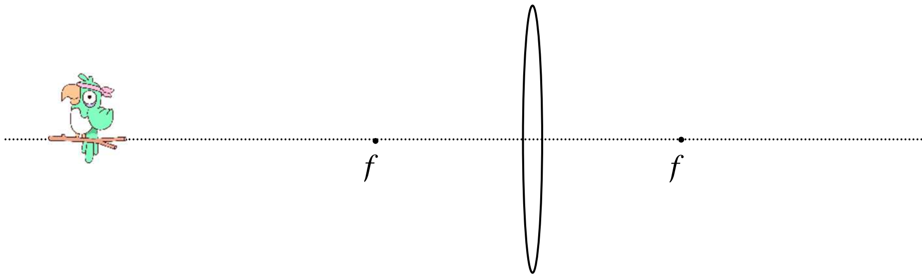

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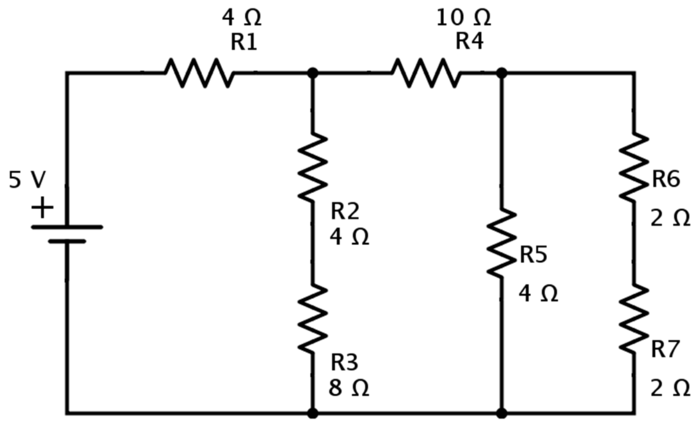

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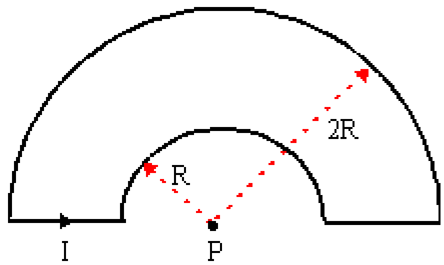

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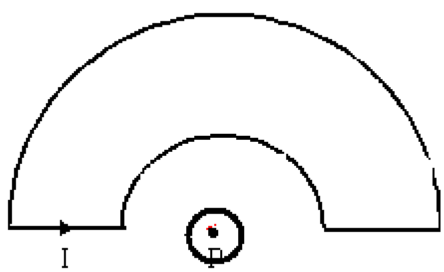

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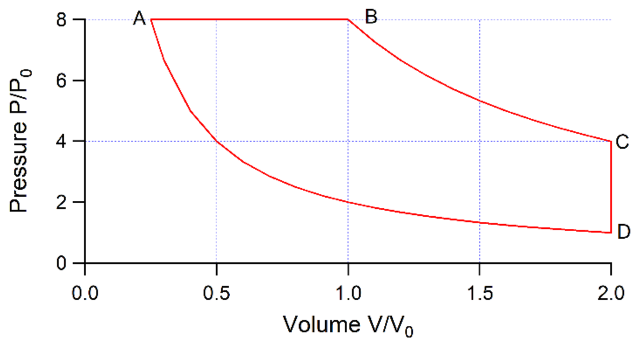

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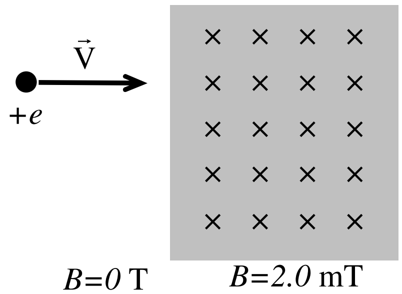

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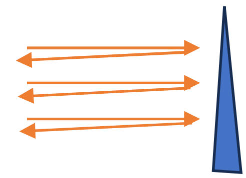

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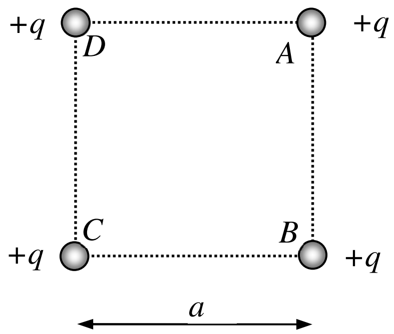

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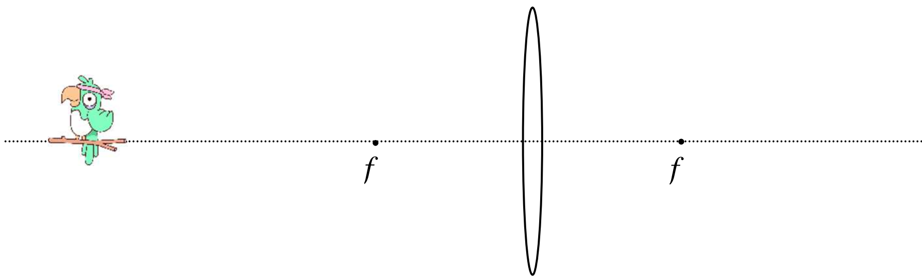

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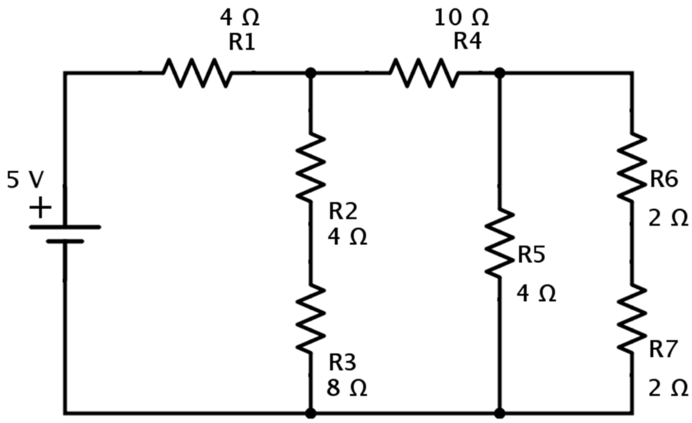

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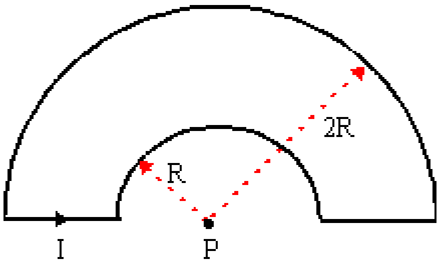

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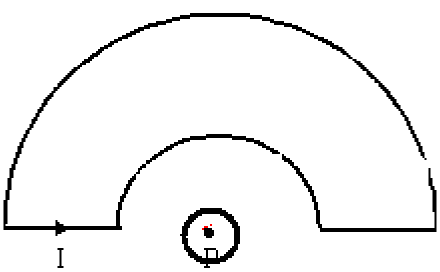

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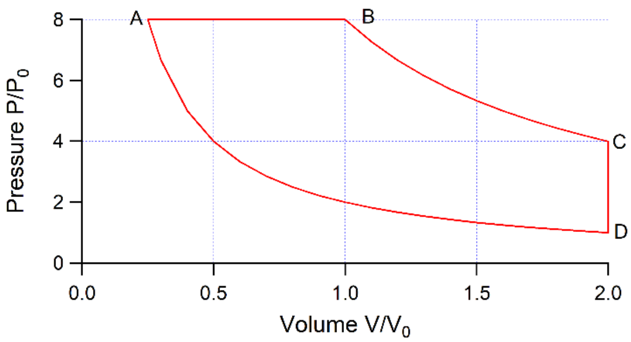

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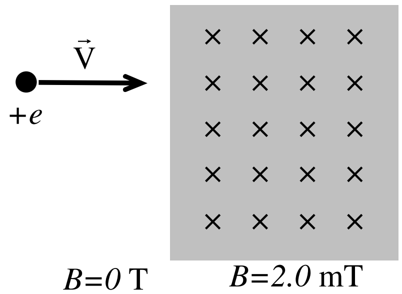

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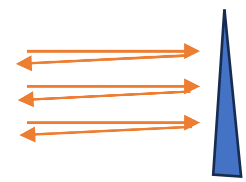

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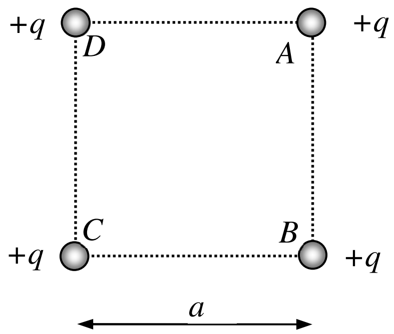

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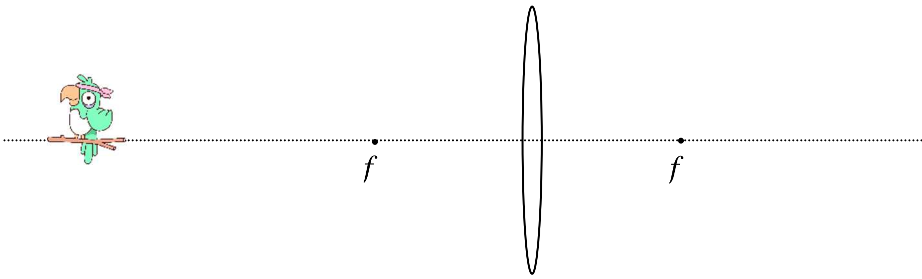

a) Calculate where the image is located with respect to the lens. Use principal ray diagram to verify your answer

b) What is the magnification of the image? Is it real or virtual? Is it upright or inverted?

c) If the bird flies away from the lens at a speed of v_0=40 cm/s, how fast does the image move? Does the image move toward or away from the lens?

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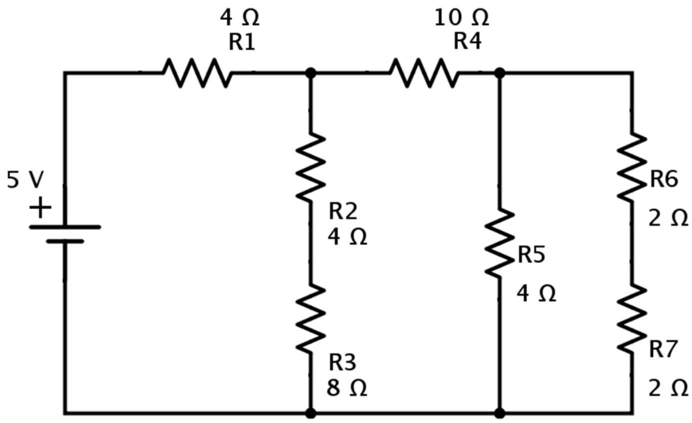

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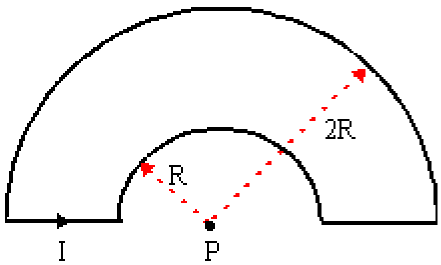

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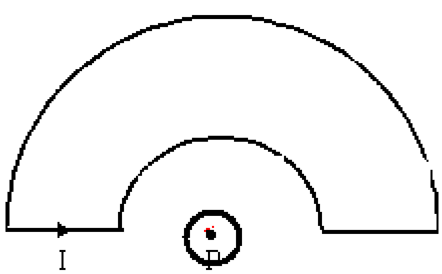

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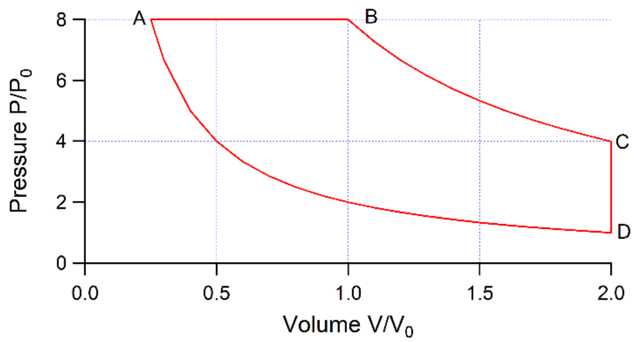

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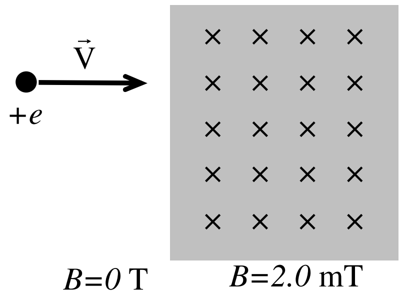

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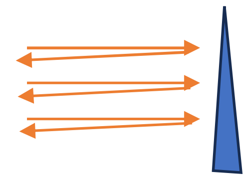

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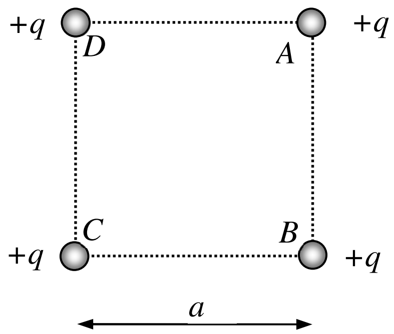

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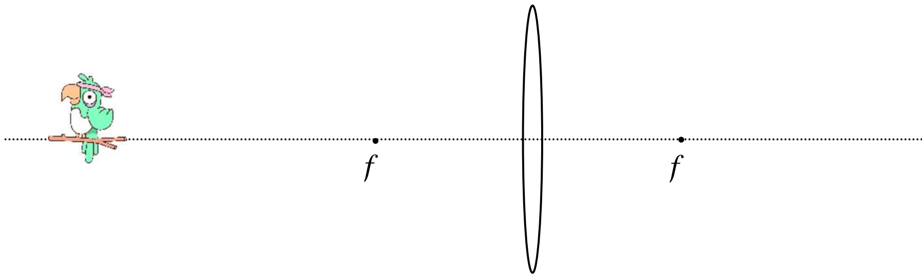

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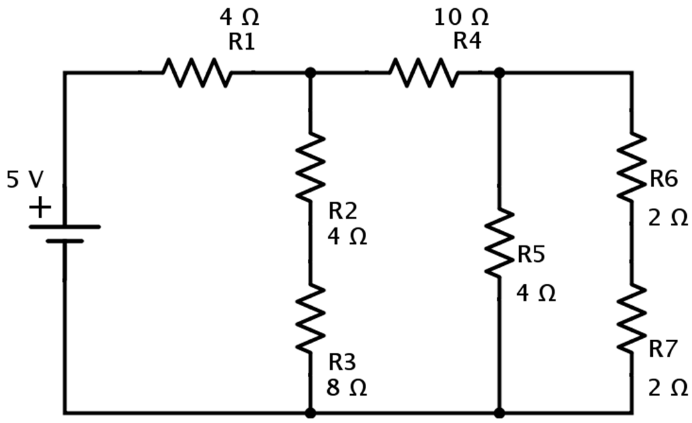

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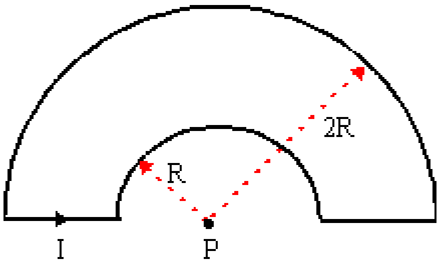

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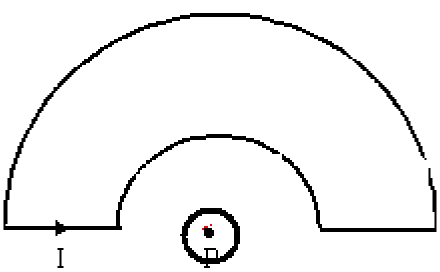

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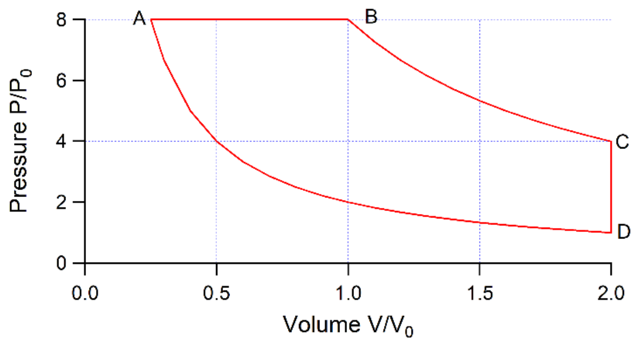

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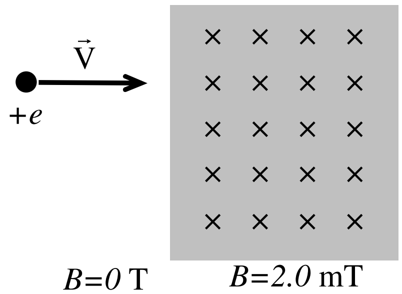

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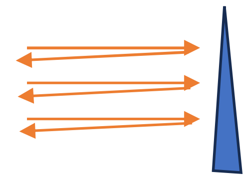

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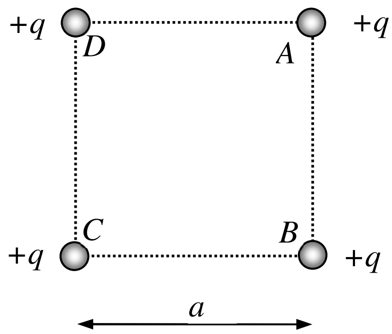

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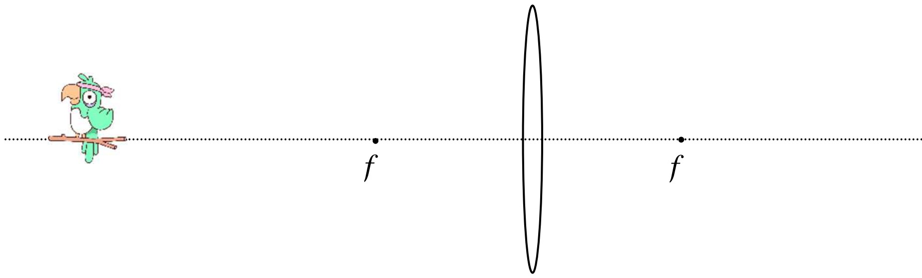

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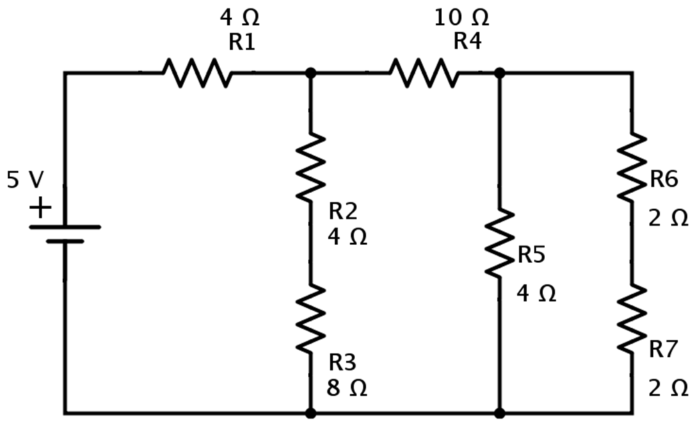

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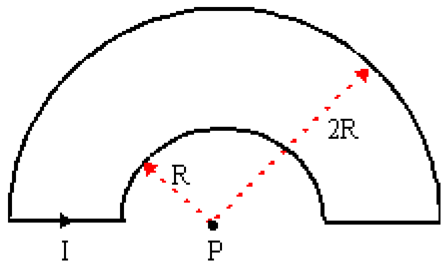

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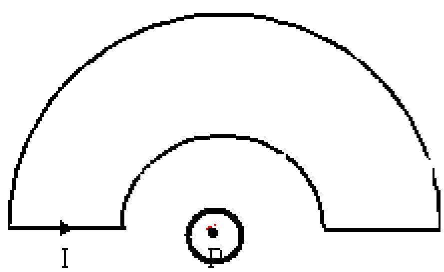

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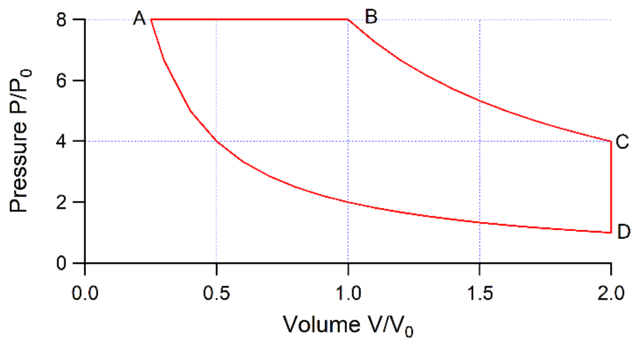

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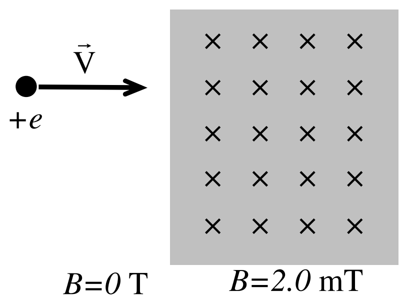

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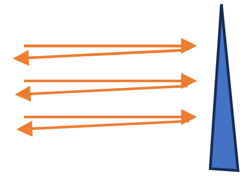

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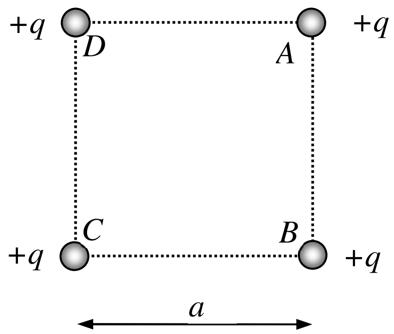

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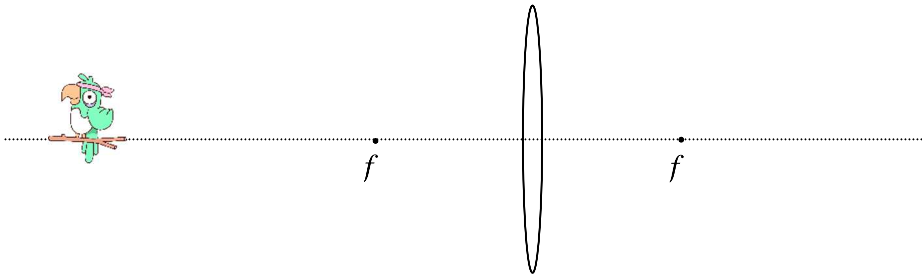

a) Calculate where the image is located with respect to the lens. Use principal ray diagram to verify your answer

b) What is the magnification of the image? Is it real or virtual? Is it upright or inverted?

c) If the bird flies away from the lens at a speed of v_0=40 cm/s, how fast does the image move? Does the image move toward or away from the lens?

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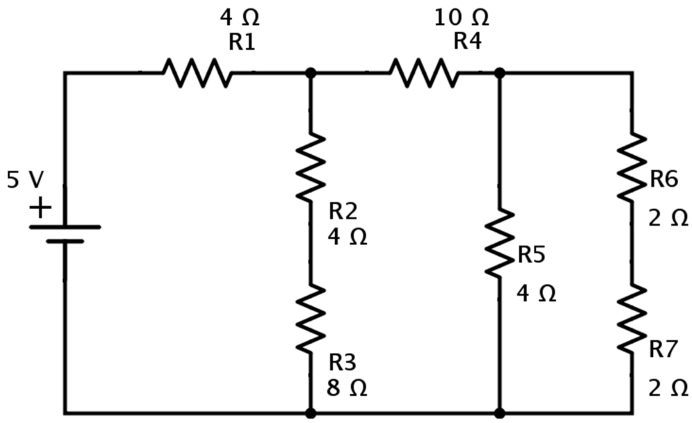

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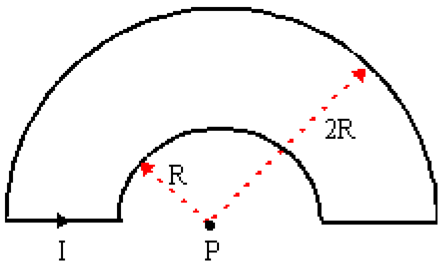

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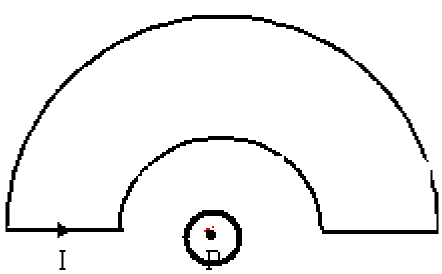

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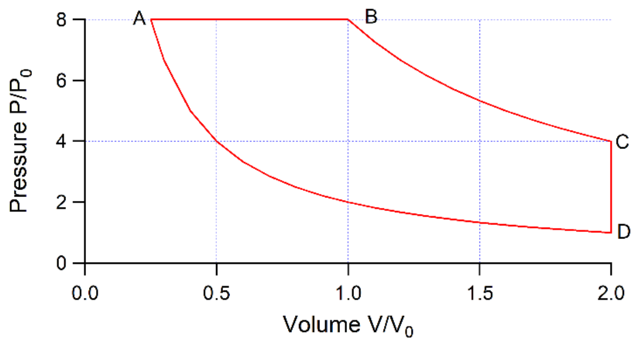

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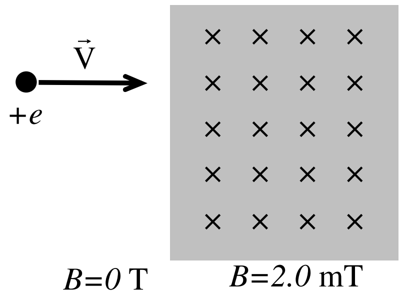

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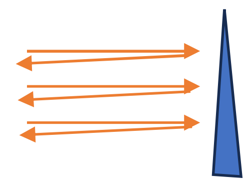

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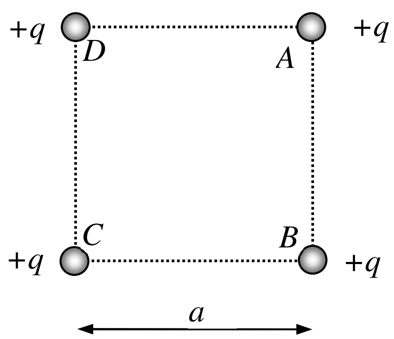

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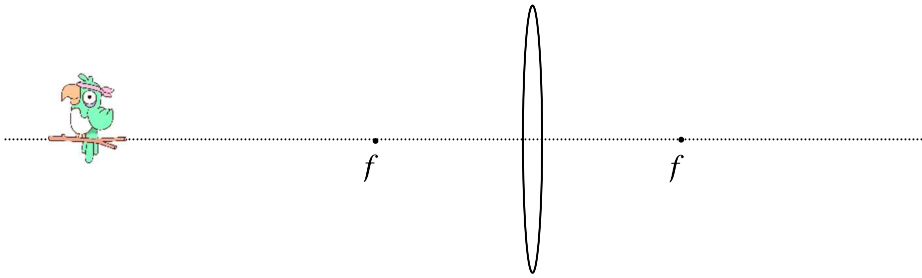

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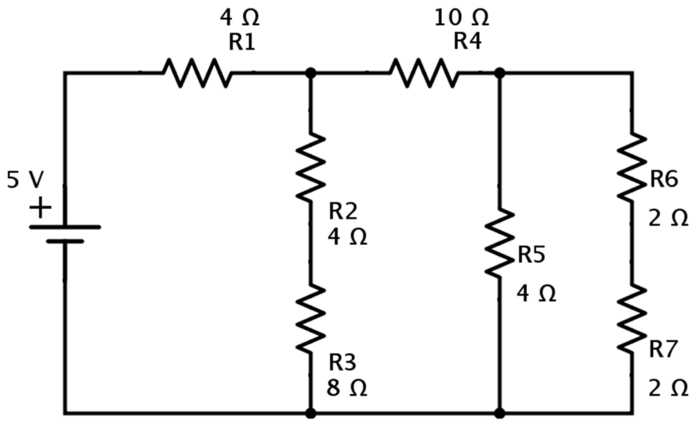

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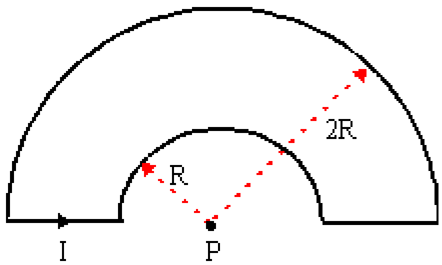

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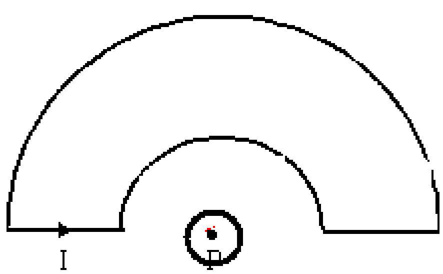

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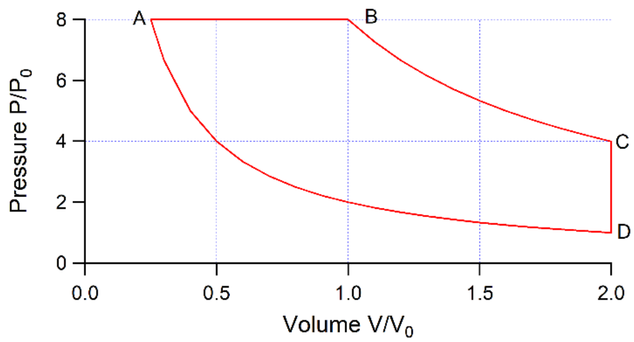

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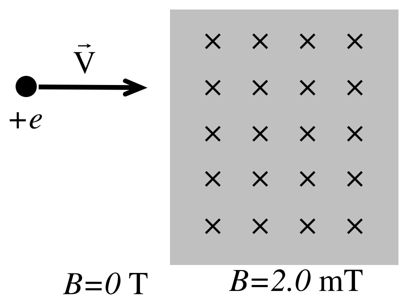

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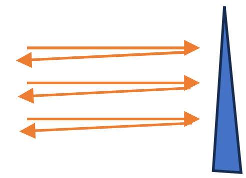

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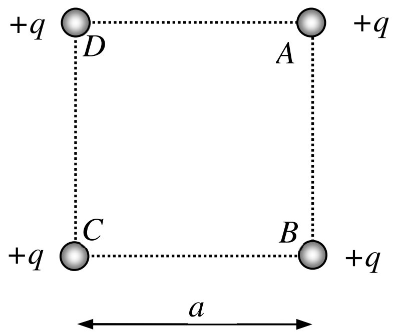

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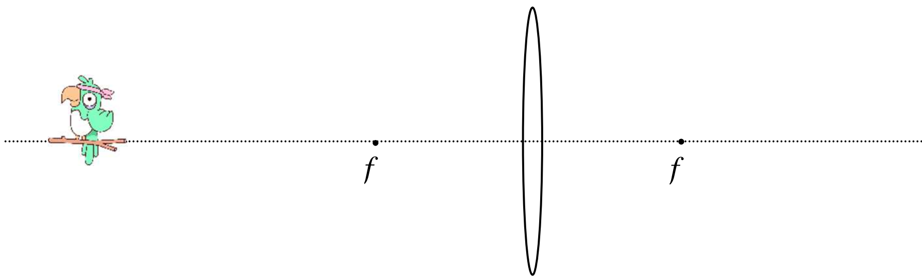

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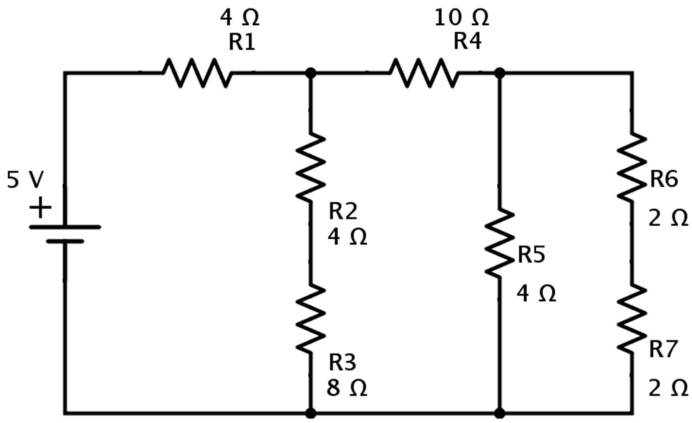

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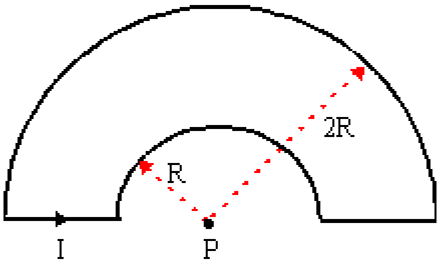

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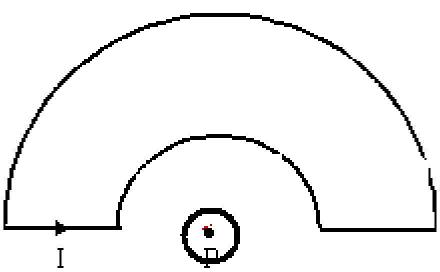

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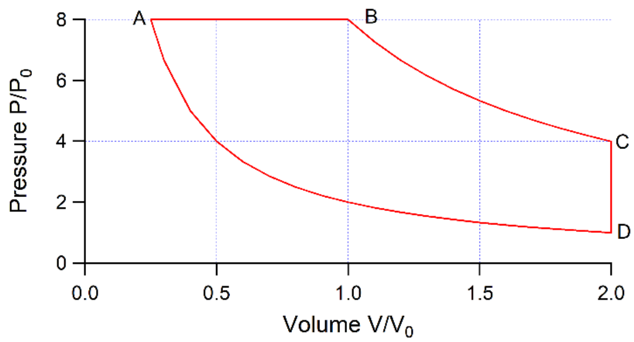

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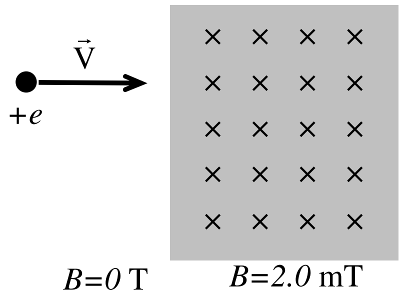

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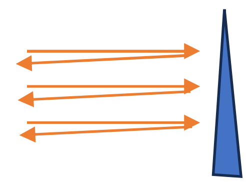

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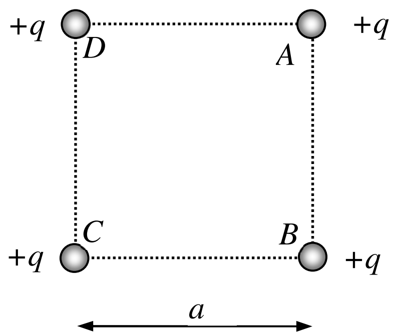

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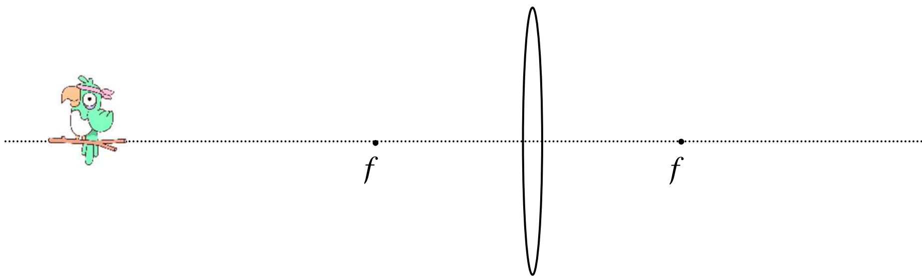

a) Calculate where the image is located with respect to the lens. Use principal ray diagram to verify your answer

b) What is the magnification of the image? Is it real or virtual? Is it upright or inverted?

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a) If the rod is completely immersed into the liquid helium, what mass of He boils off by the time the rod cools to 4.2 K?

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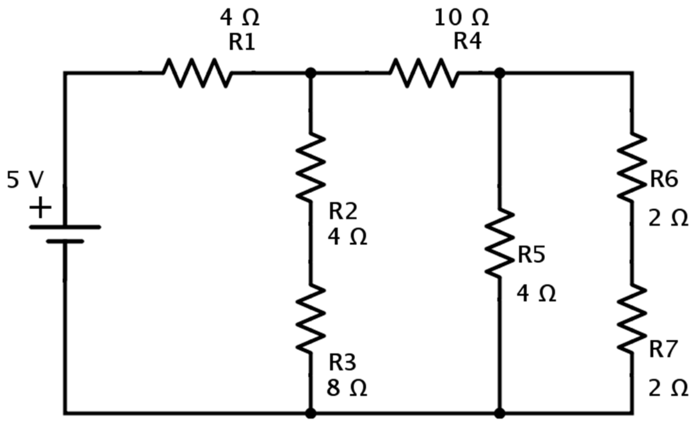

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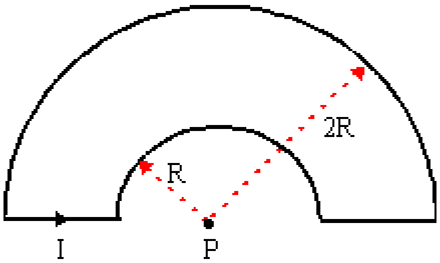

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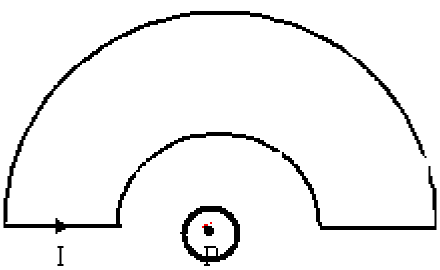

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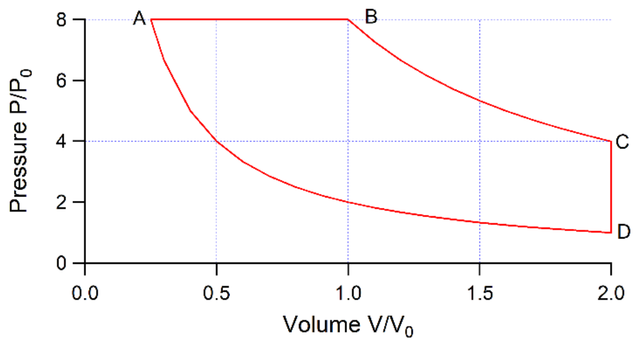

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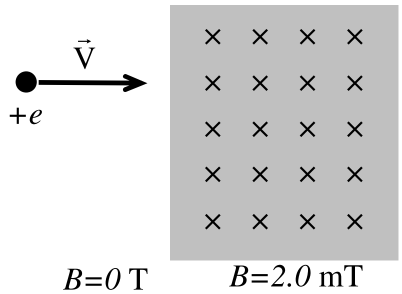

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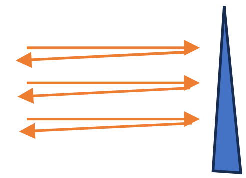

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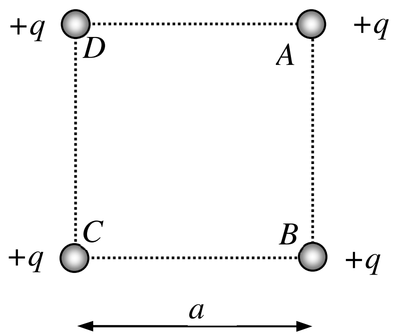

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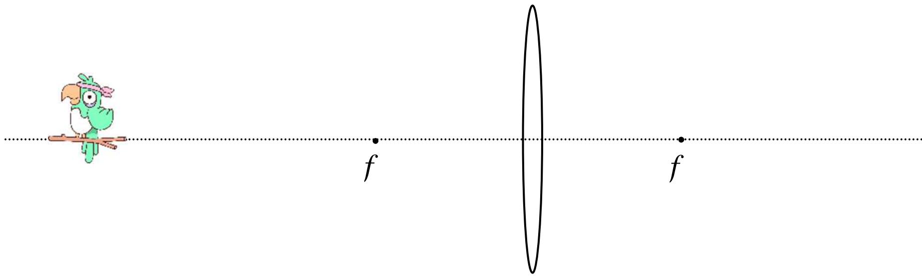

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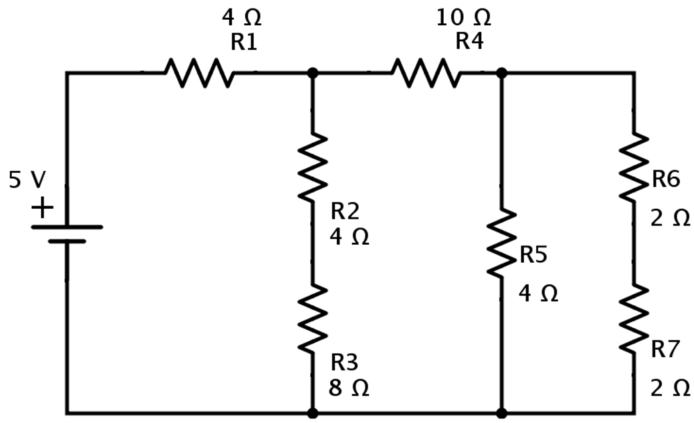

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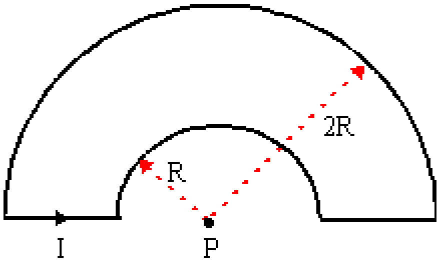

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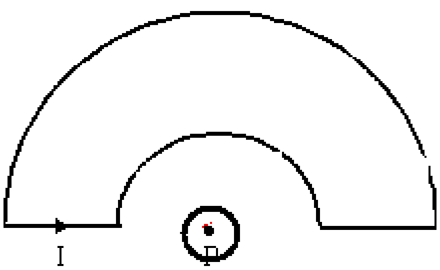

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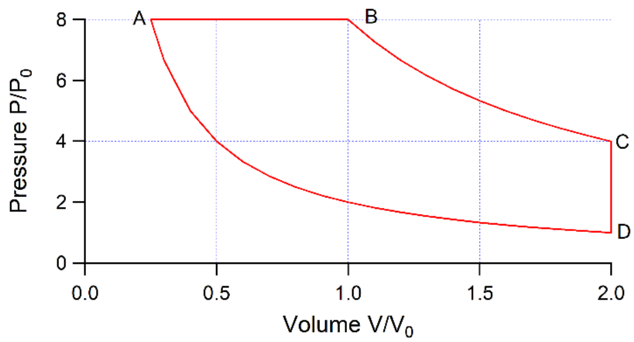

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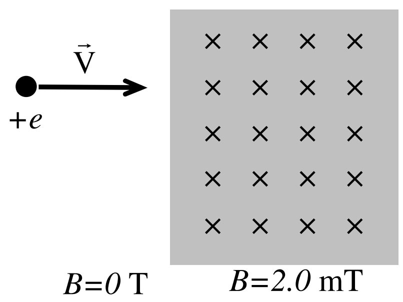

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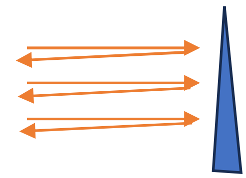

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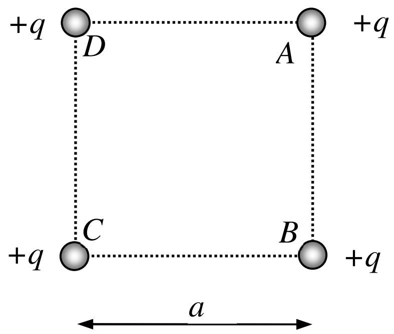

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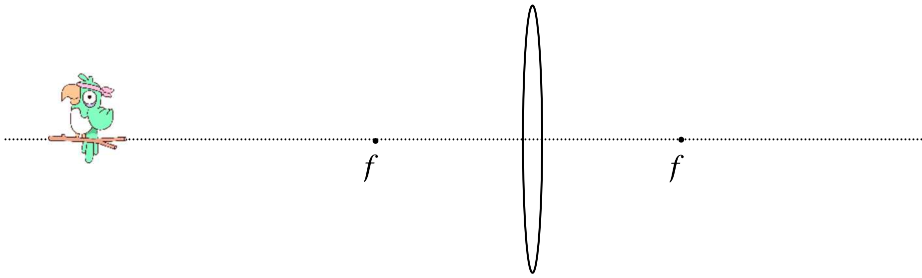

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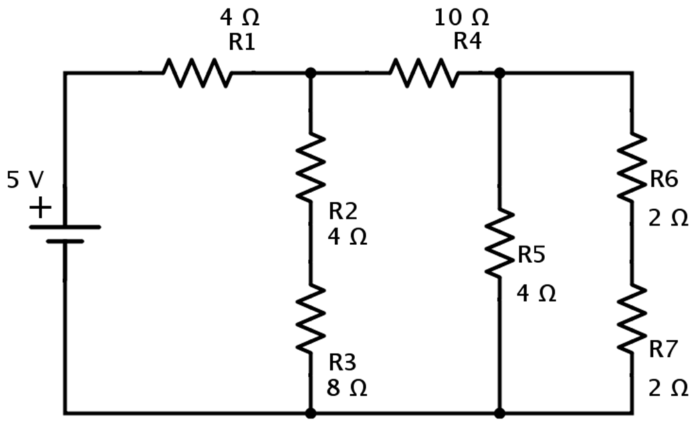

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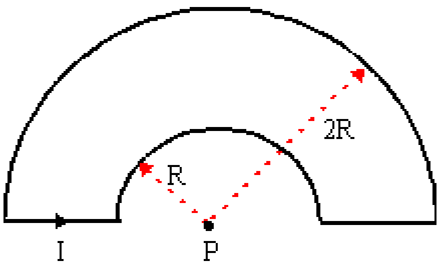

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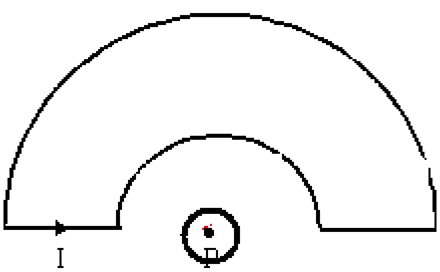

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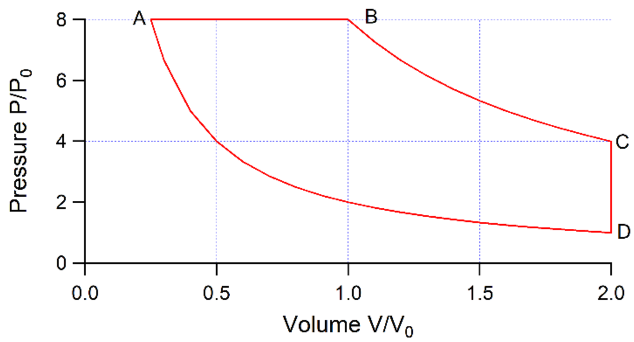

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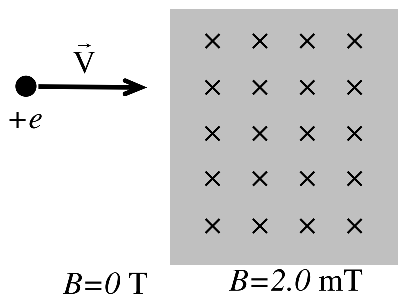

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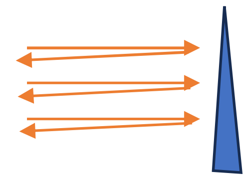

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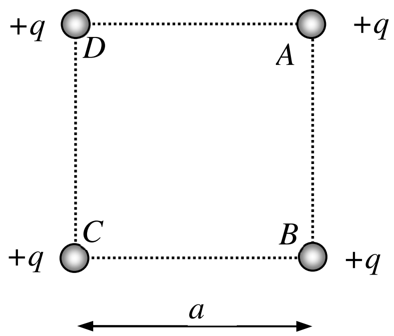

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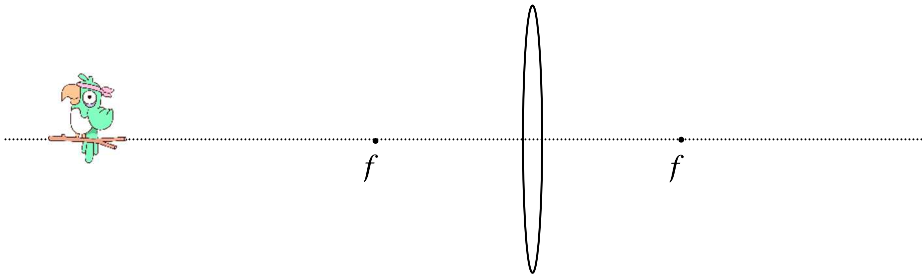

a) Calculate where the image is located with respect to the lens. Use principal ray diagram to verify your answer

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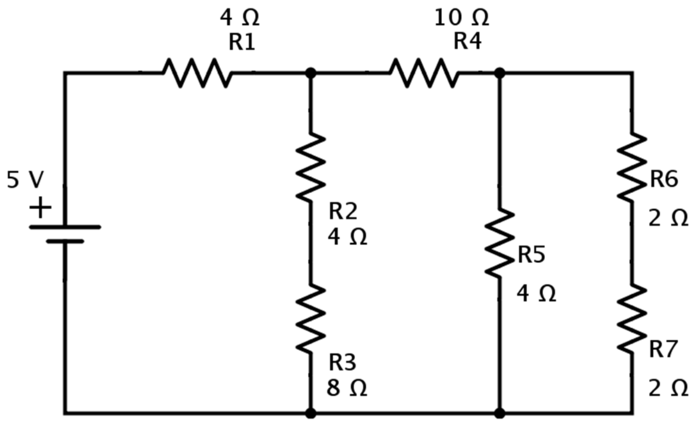

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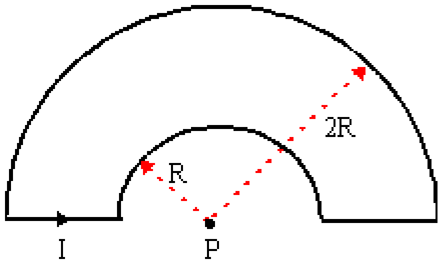

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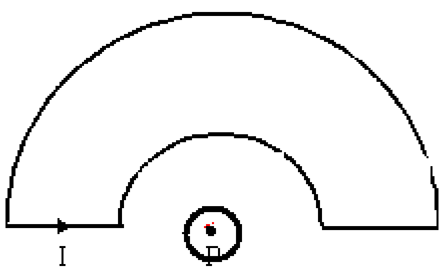

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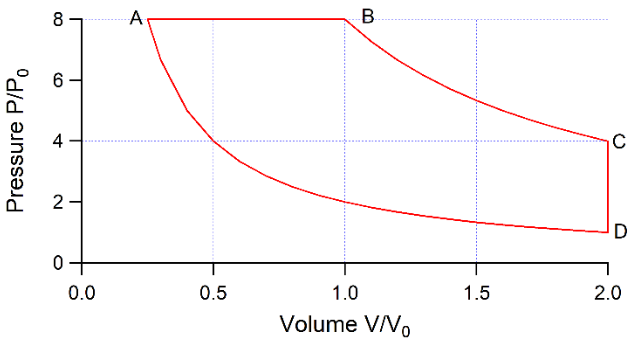

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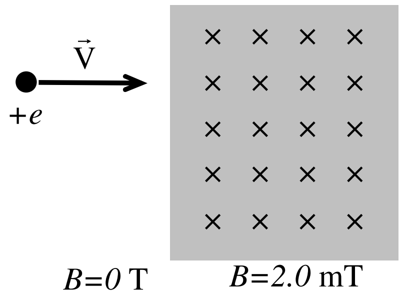

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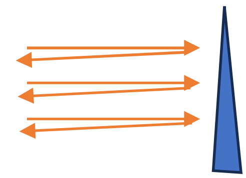

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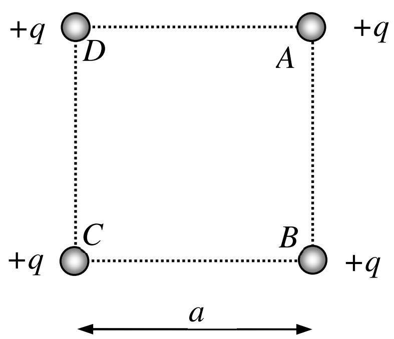

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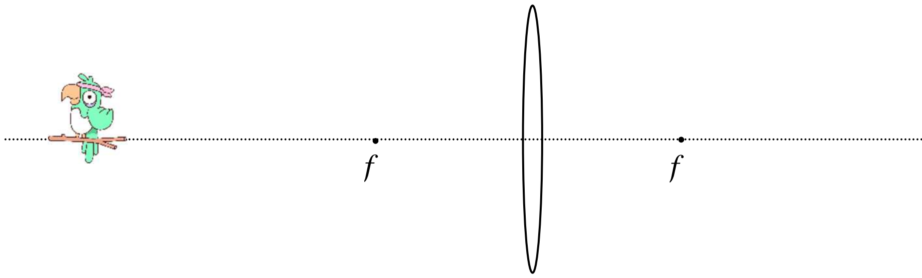

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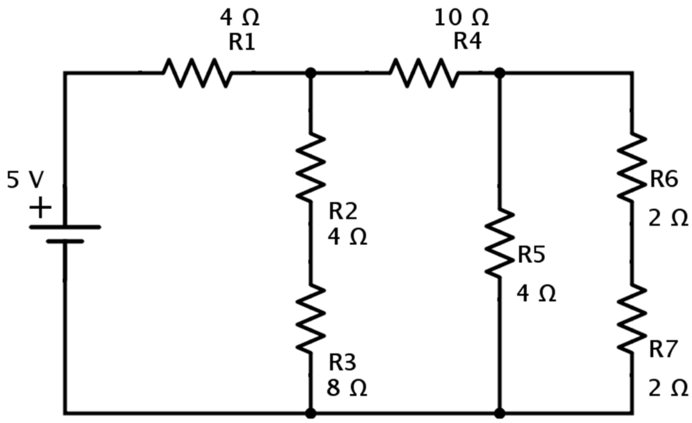

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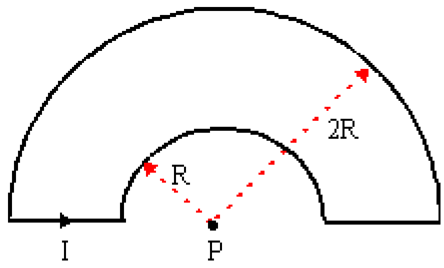

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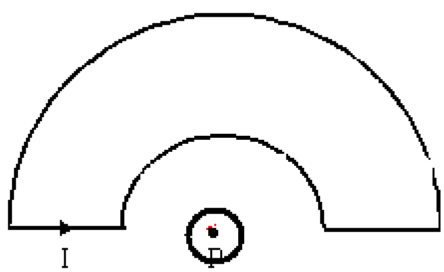

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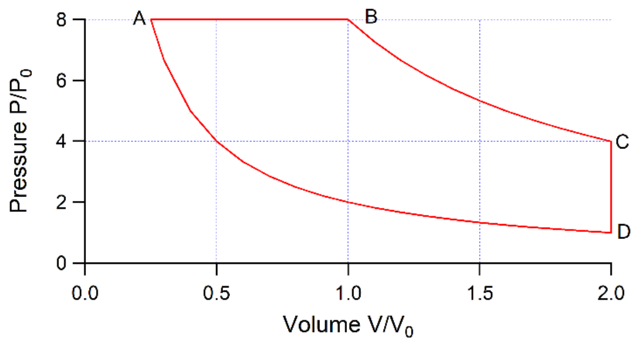

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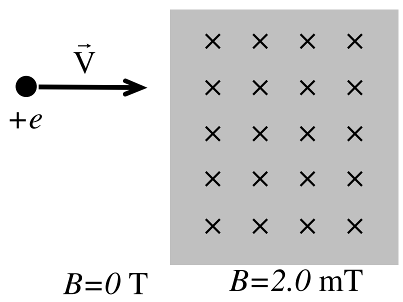

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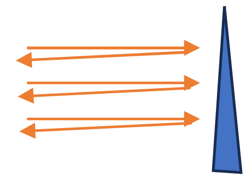

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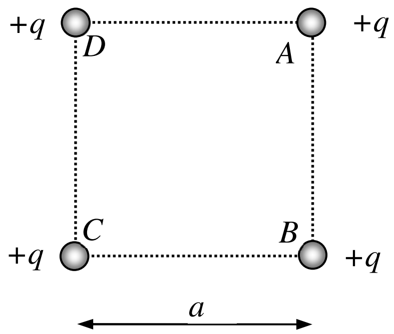

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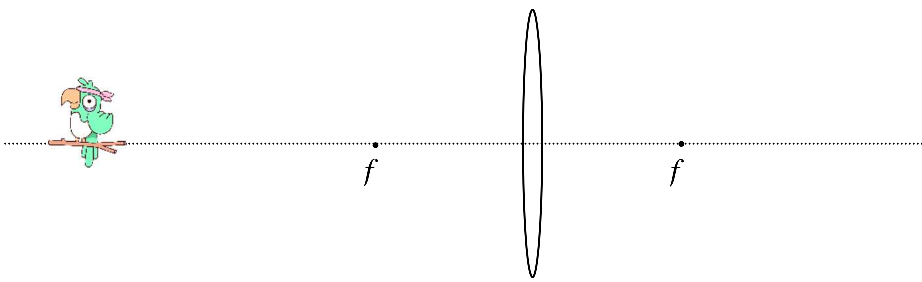

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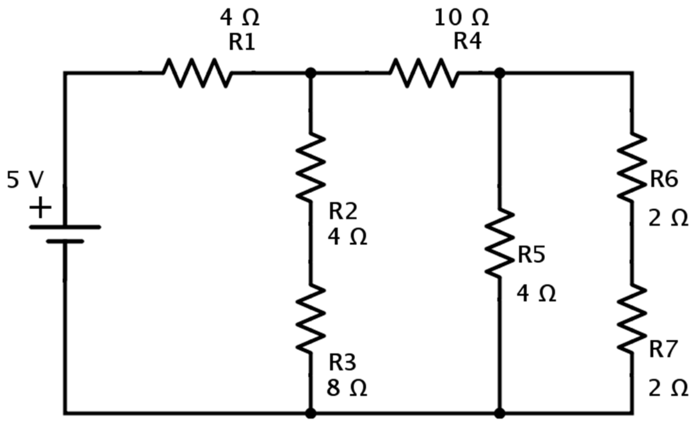

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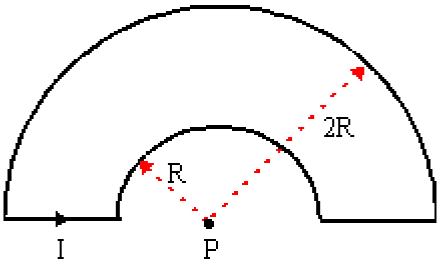

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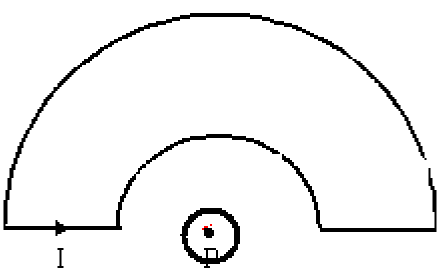

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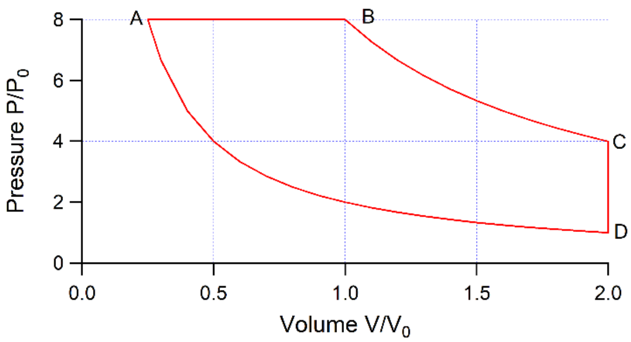

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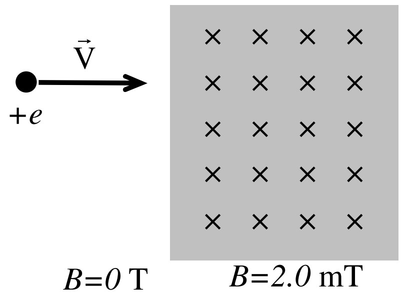

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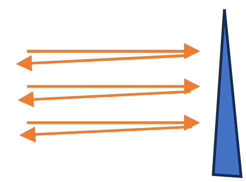

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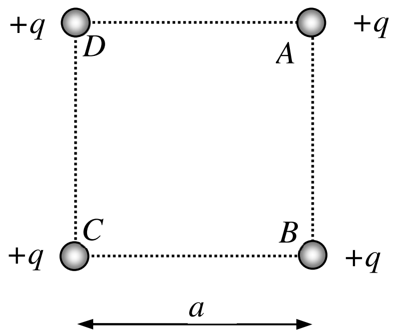

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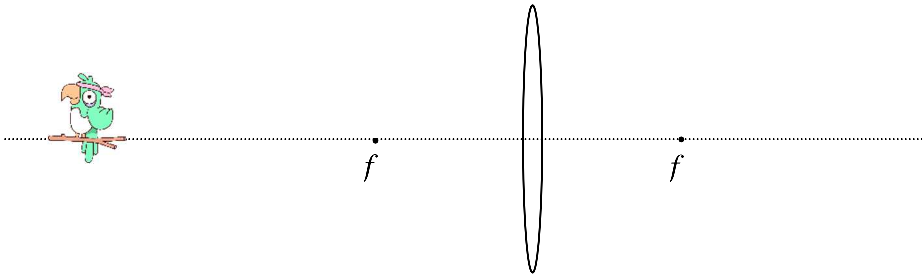

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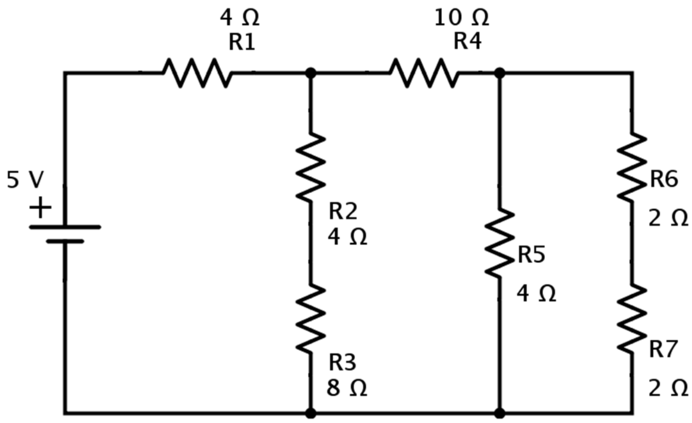

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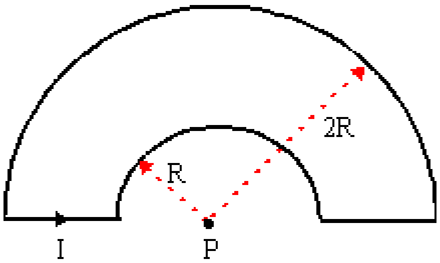

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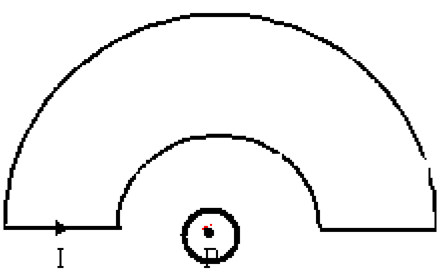

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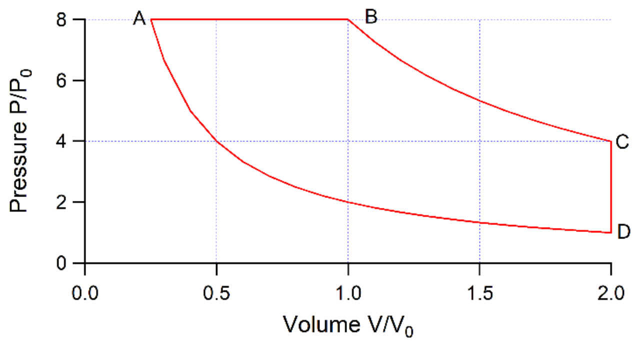

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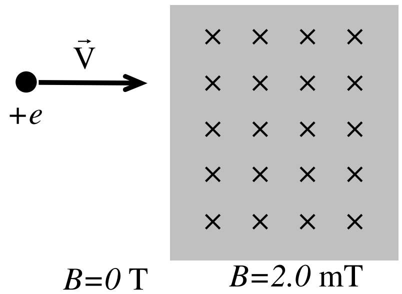

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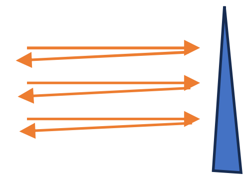

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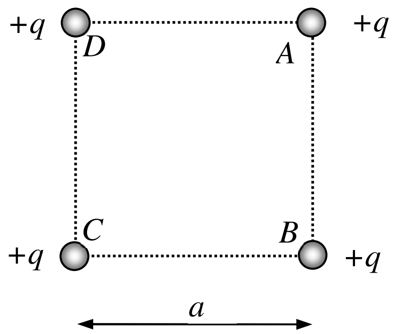

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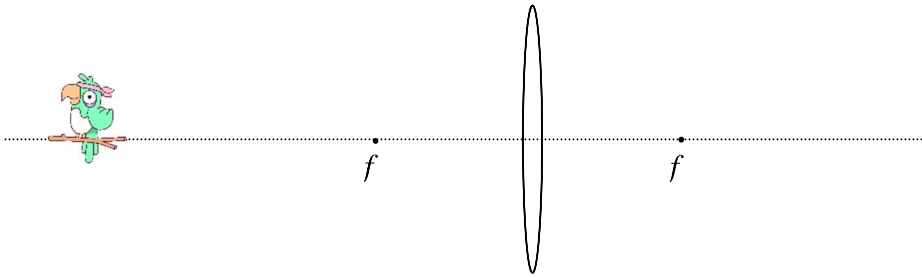

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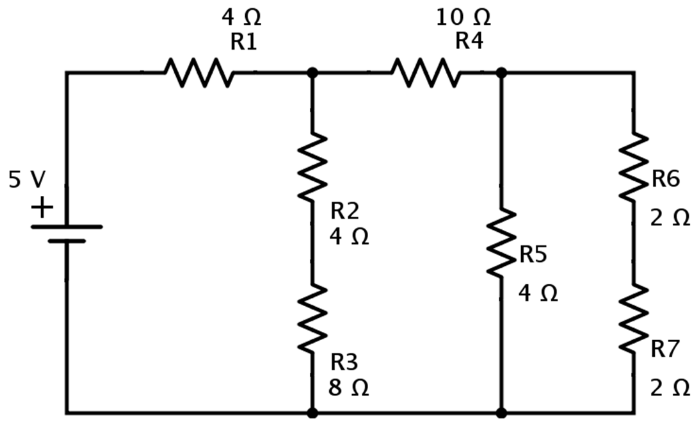

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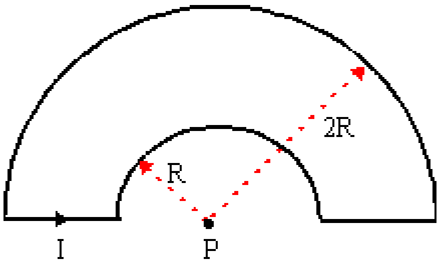

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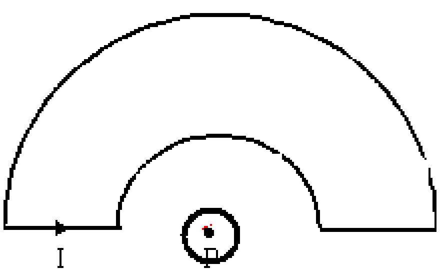

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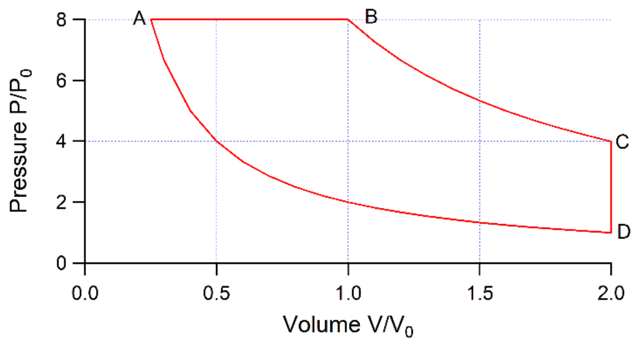

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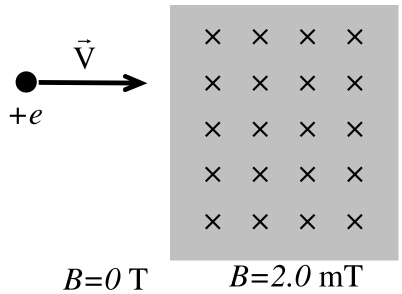

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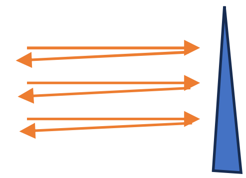

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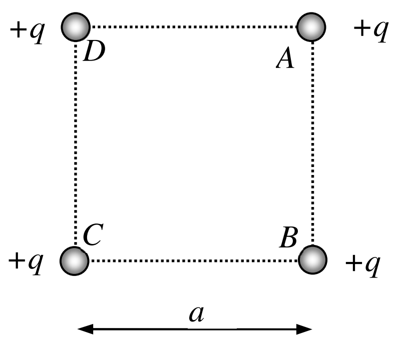

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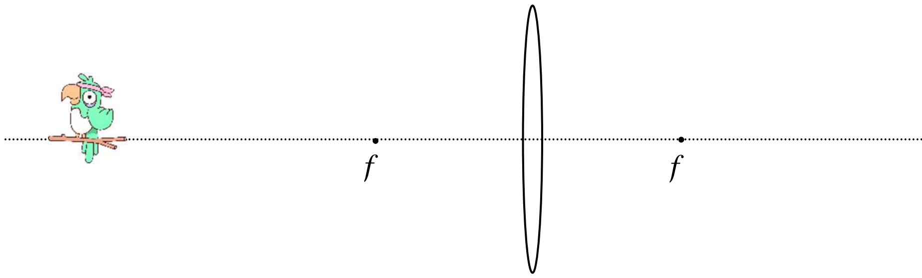

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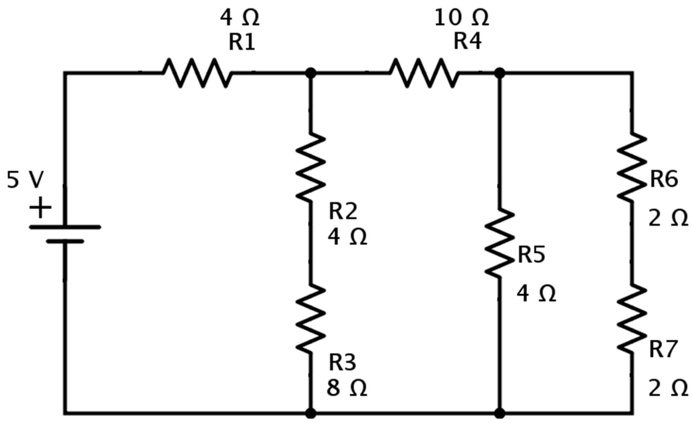

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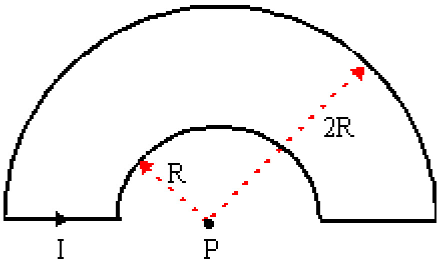

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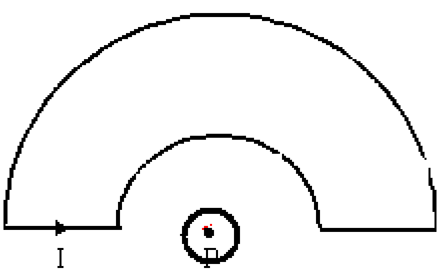

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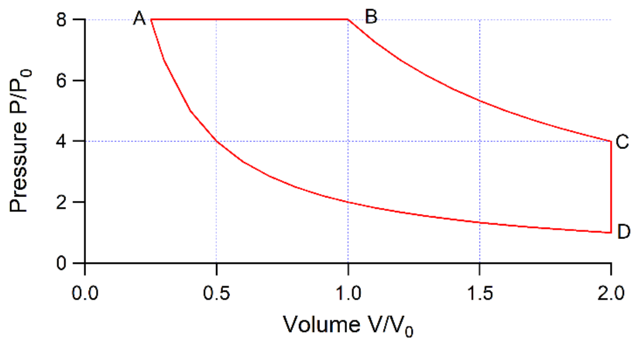

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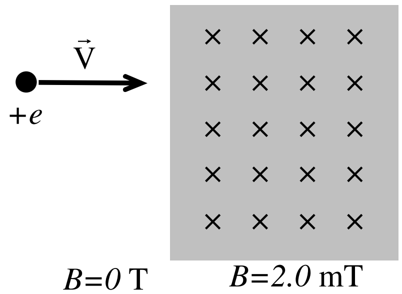

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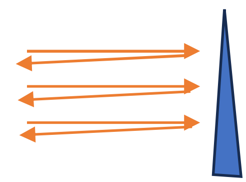

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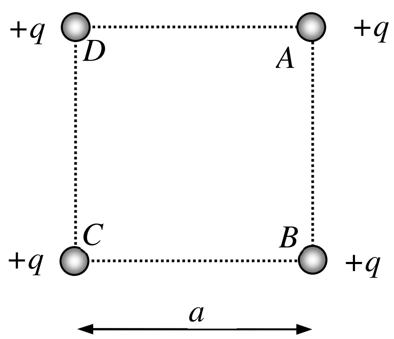

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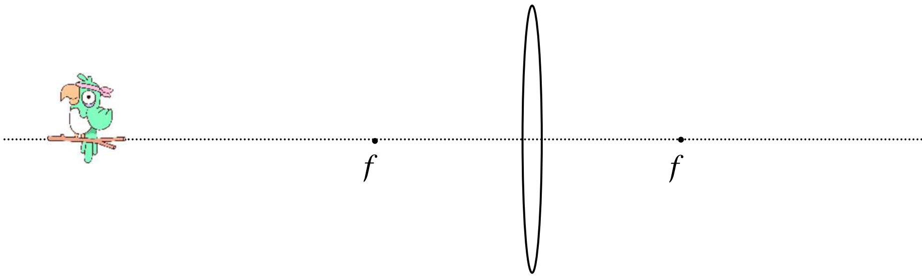

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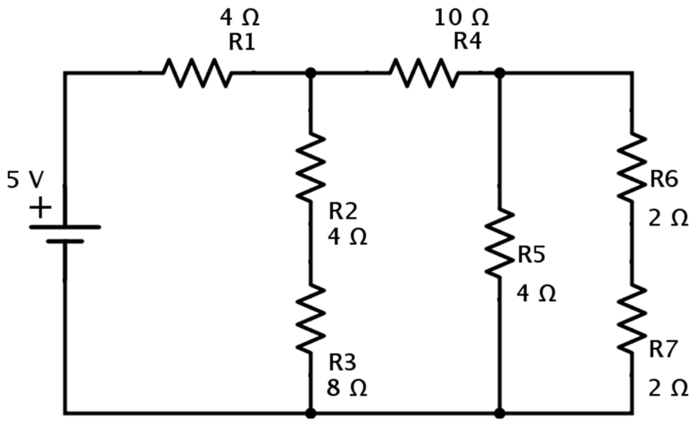

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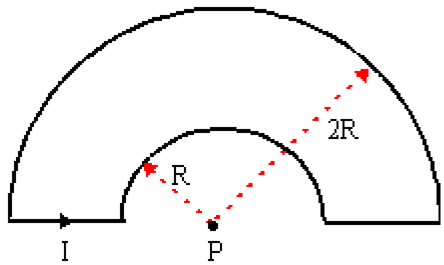

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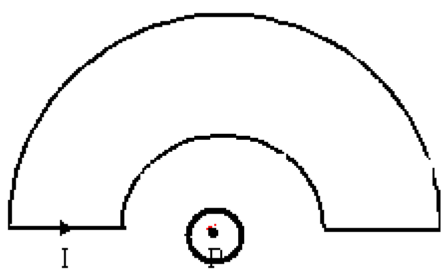

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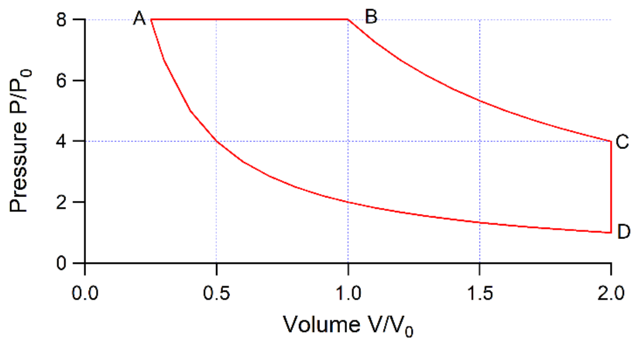

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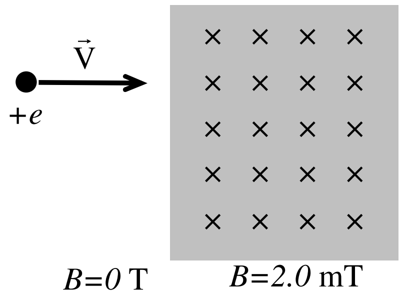

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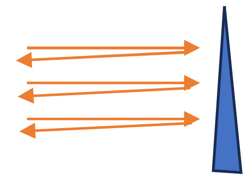

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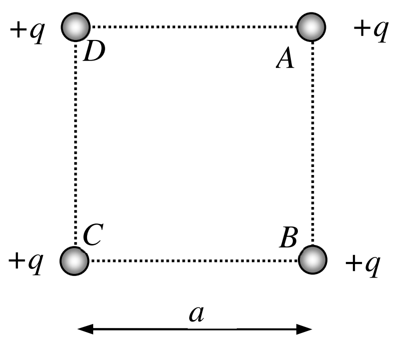

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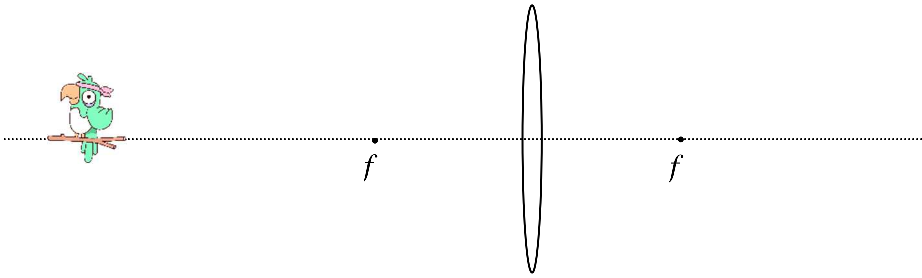

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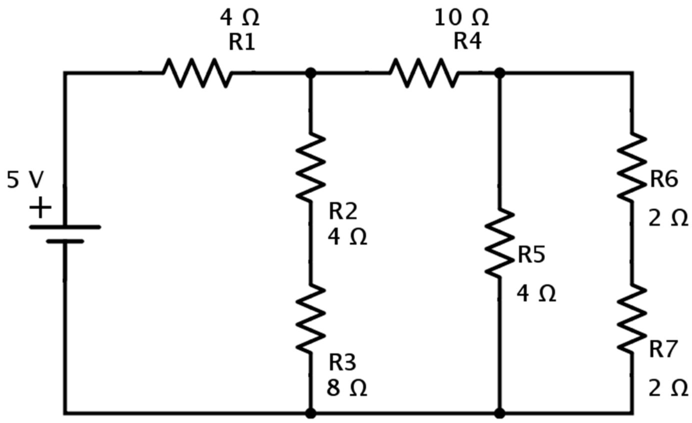

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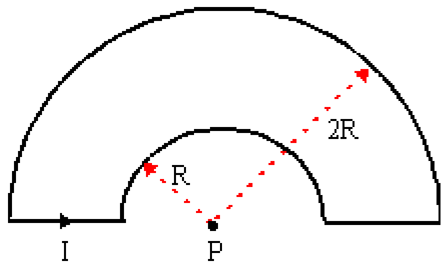

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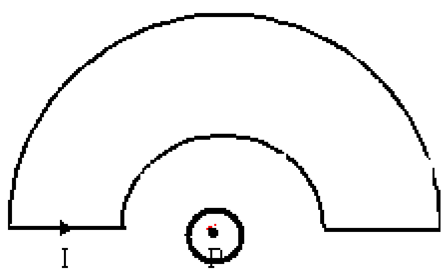

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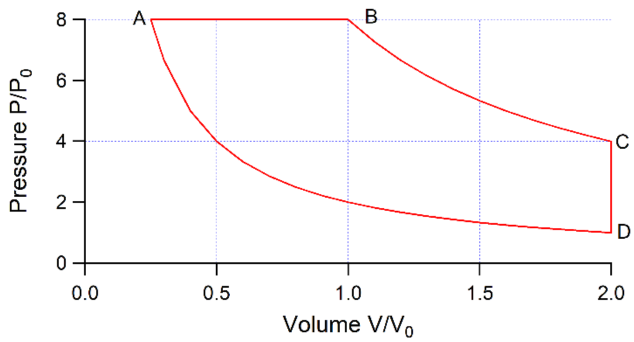

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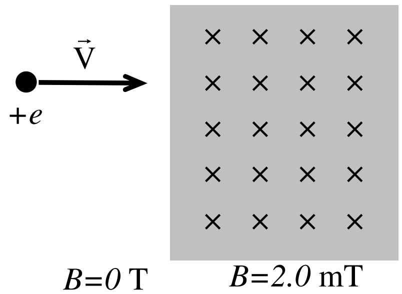

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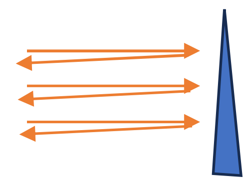

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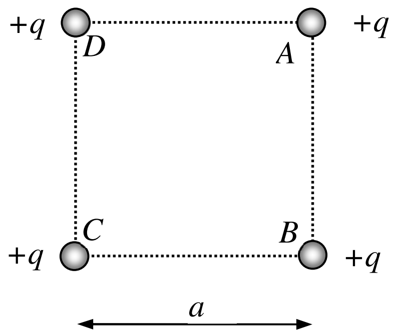

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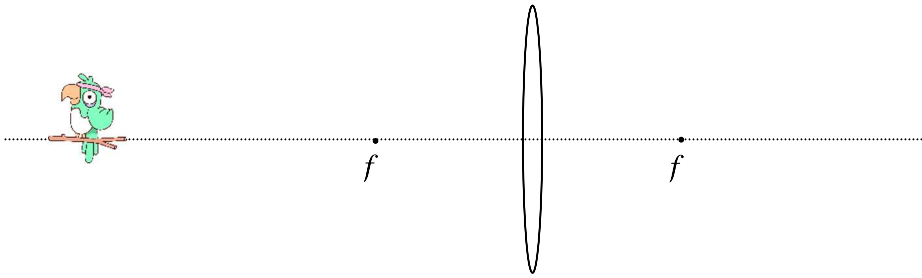

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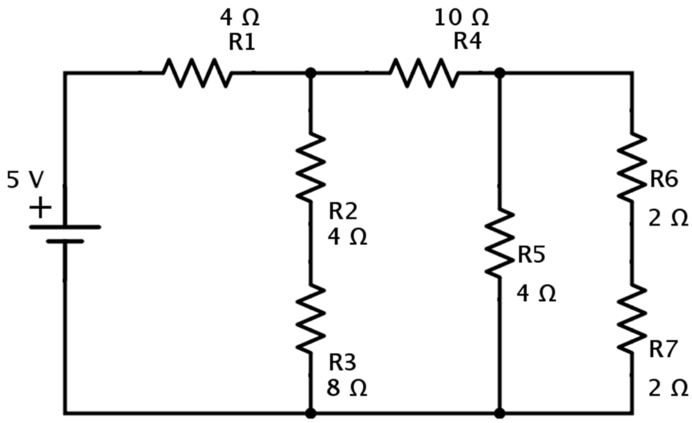

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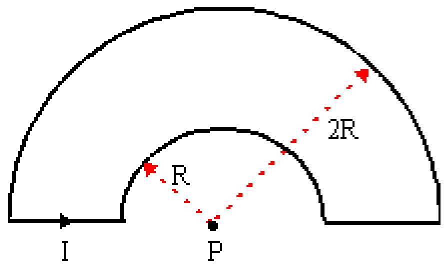

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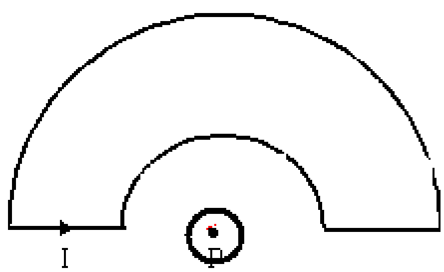

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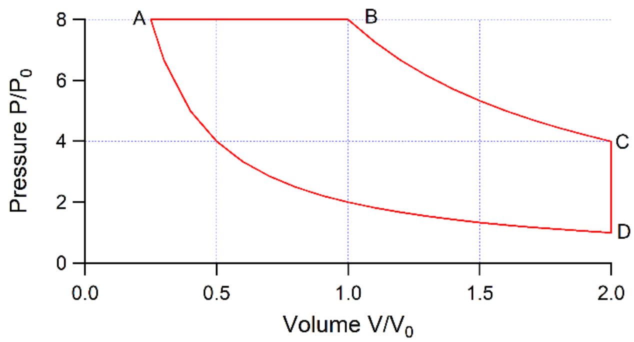

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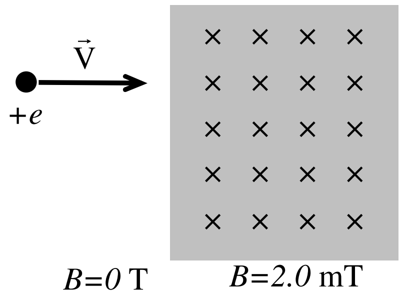

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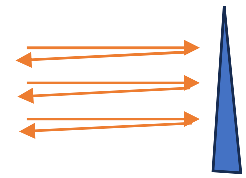

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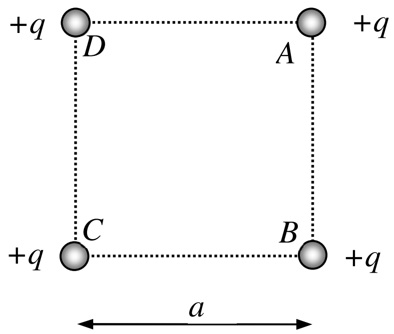

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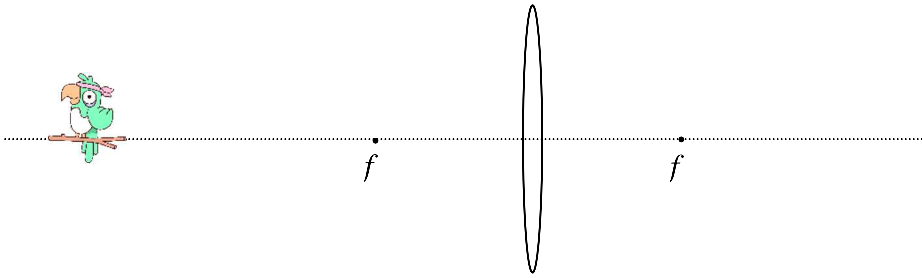

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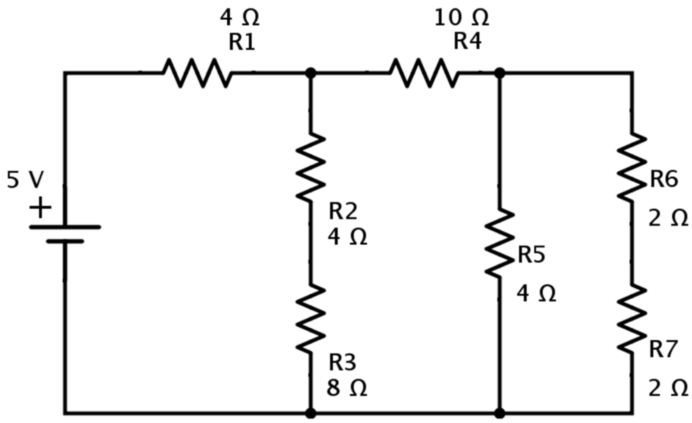

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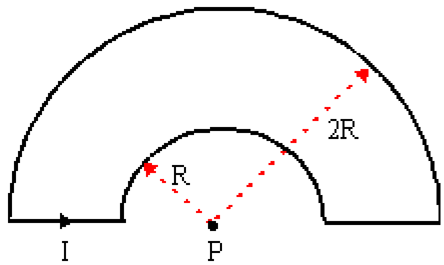

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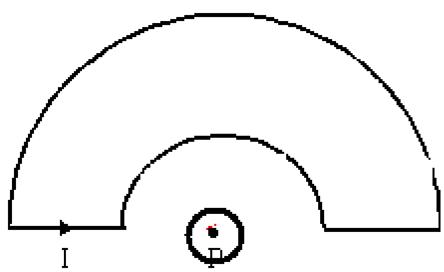

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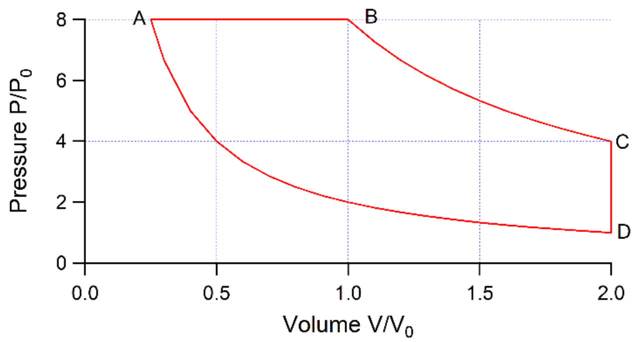

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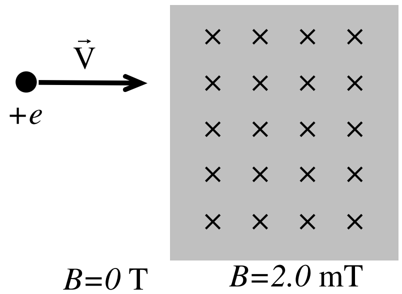

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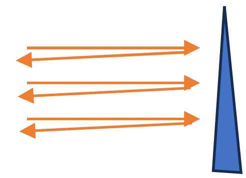

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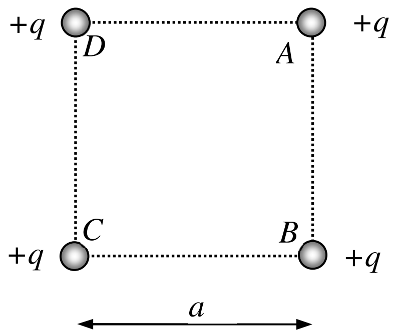

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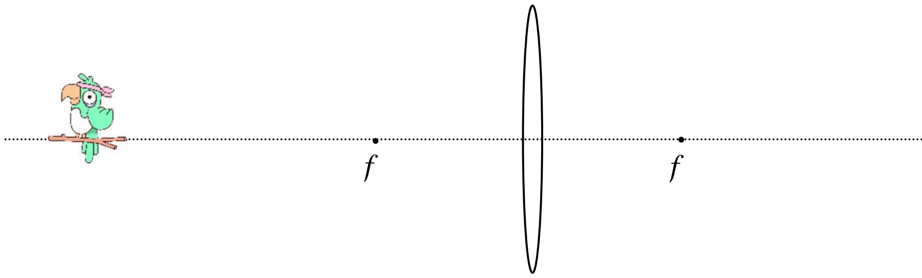

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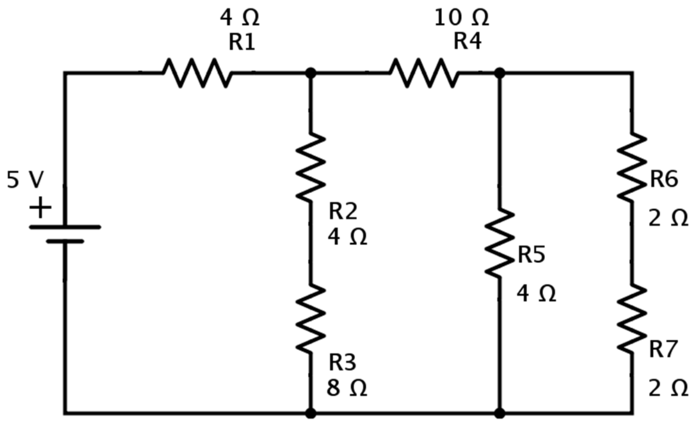

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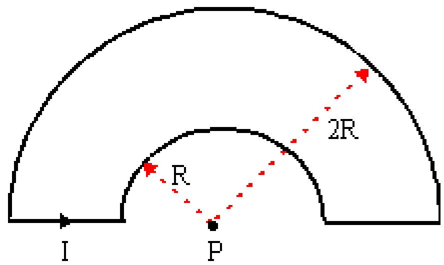

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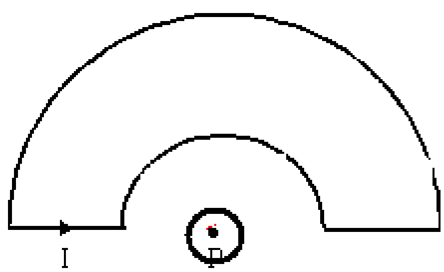

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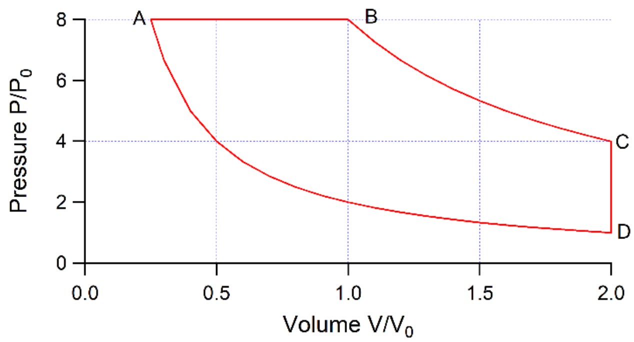

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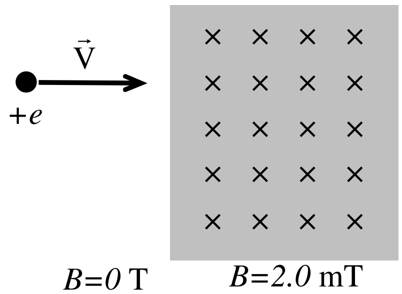

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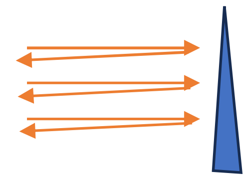

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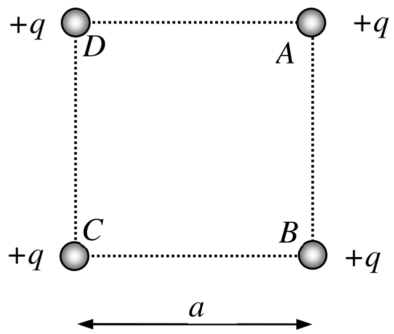

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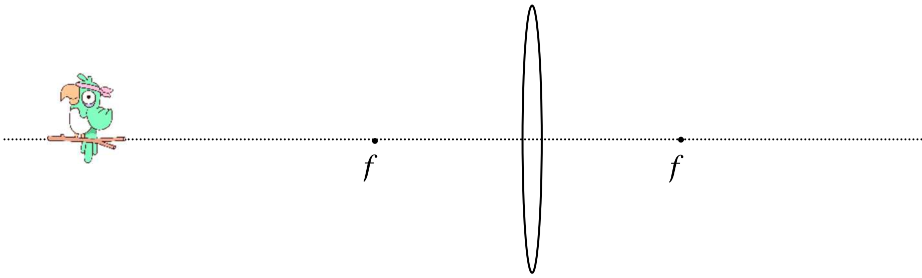

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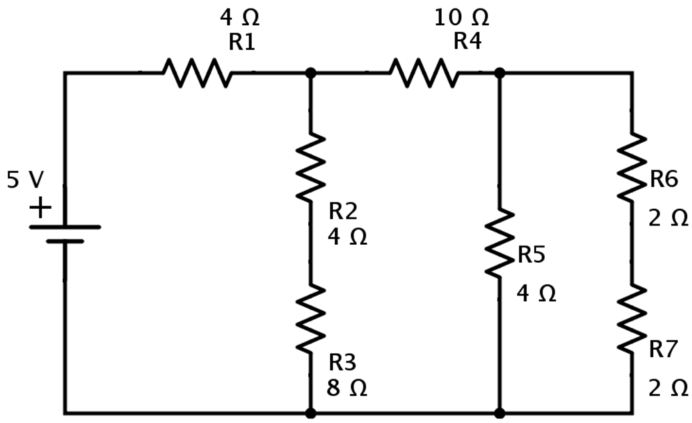

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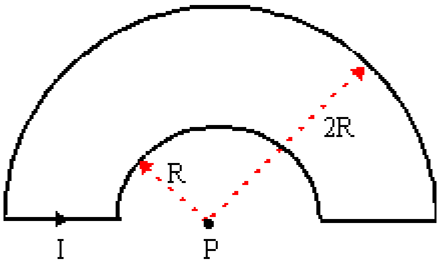

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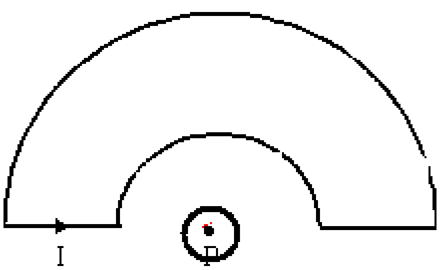

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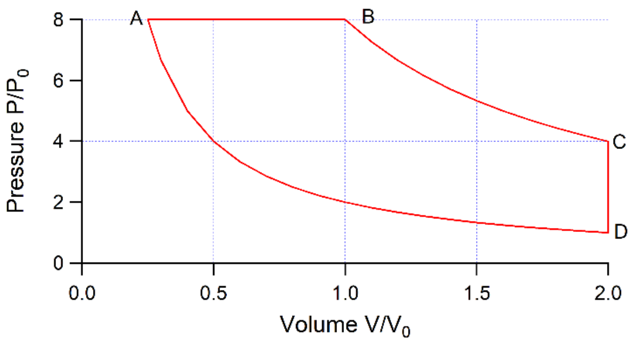

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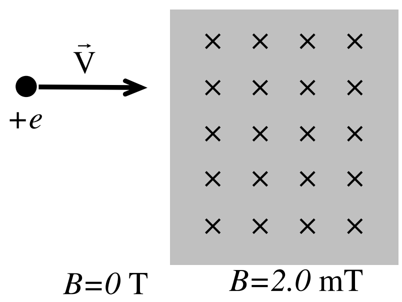

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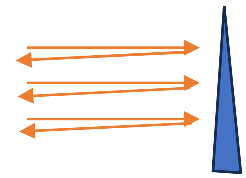

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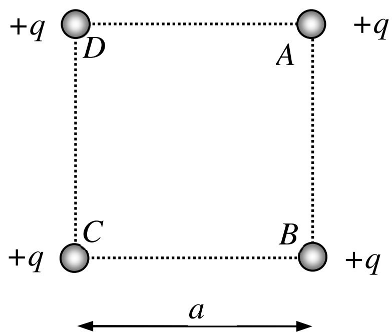

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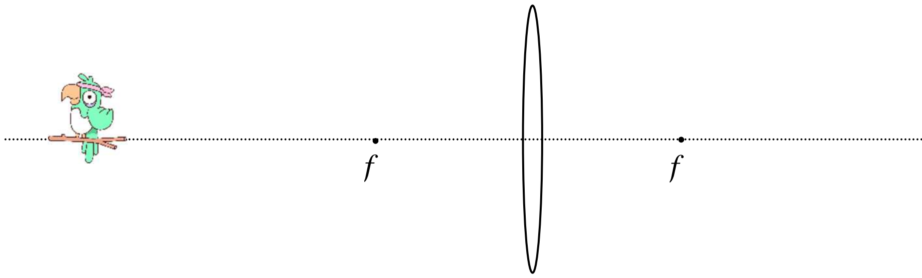

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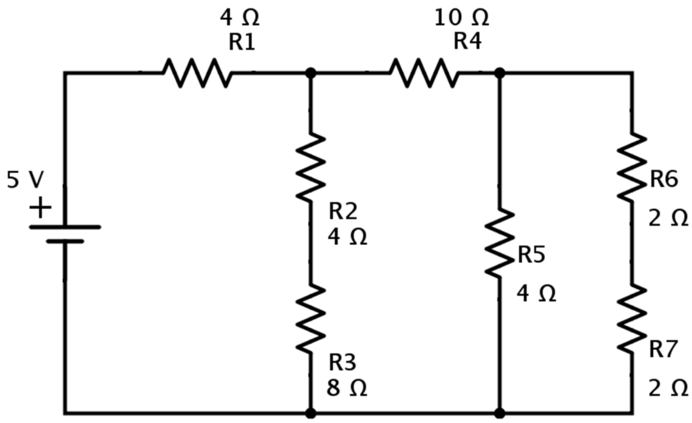

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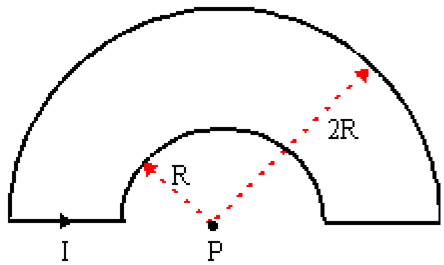

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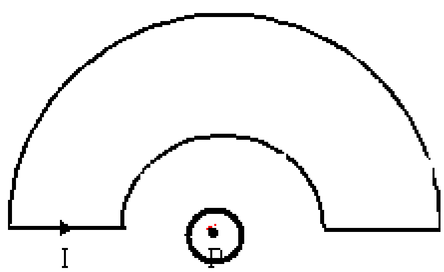

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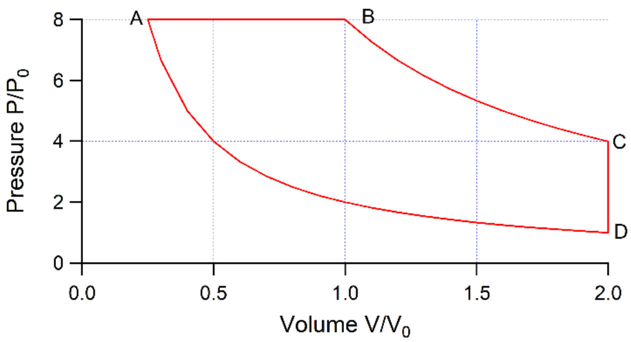

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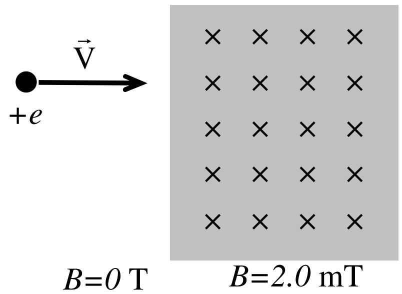

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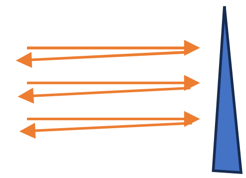

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