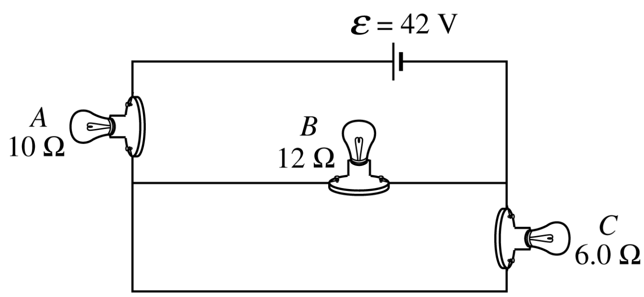
2000 AP® PHYSICS C FREE-RESPONSE QUESTIONS

PHYSICS C

Section II, ELECTRICITY AND MAGNETISM
Time—45 minutes
3 Questions

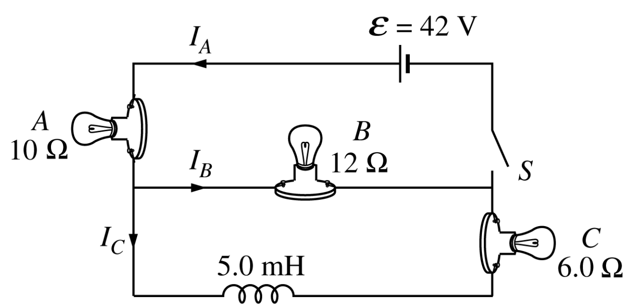
Directions: Answer all three questions. The suggested time is about 15 minutes for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight. Show all your work in the pink booklet in the spaces provided after each part, NOT in this green insert.



E & M 1.

Lightbulbs A, B, and C are connected in the circuit shown above.

(a) List the bulbs in order of their brightness, from brightest to least bright. If any bulbs have the same brightness, state which ones. Justify your answer.



Now a switch S and a 5.0 mH inductor are added to the circuit, as shown above. The switch is closed at time $t = 0$.

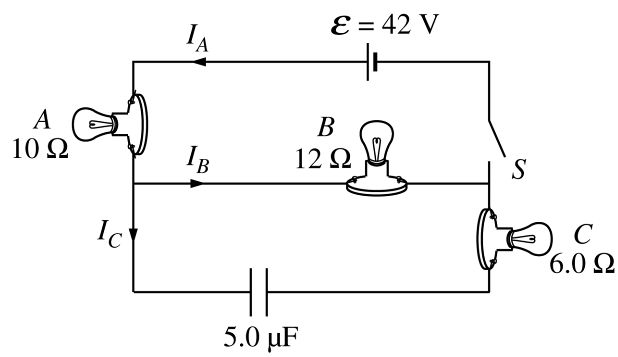
(b) Determine the currents I_A, I_B, and I_C for the following times.

i. Immediately after the switch is closed

ii. A long time after the switch is closed

GO ON TO THE NEXT PAGE.

(c) On the axes below, sketch the magnitude of the potential difference V_L across the inductor as a function of time, from immediately after the switch is closed until a long time after the switch is closed.



(d) Now consider a similar circuit with an uncharged 5.0 μF capacitor instead of the inductor, as shown above. The switch is again closed at time $t = 0$. On the axes below, sketch the magnitude of the potential difference V_{cap} across the capacitor as a function of time, from immediately after the switch is closed until a long time after the switch is closed.

E & M 2.

Three particles, A, B, and C, have equal positive charges Q and are held in place at the vertices of an equilateral triangle with sides of length ℓ, as shown in the figures below. The dotted lines represent the bisectors for each side. The base of the triangle lies on the x-axis, and the altitude of the triangle lies on the y-axis.

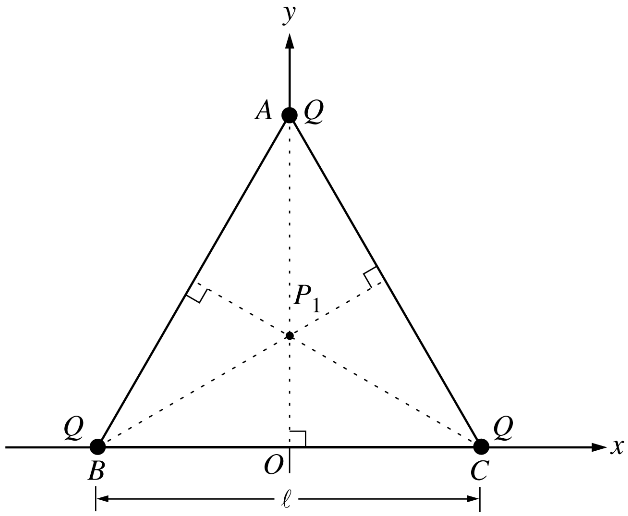


Figure 1

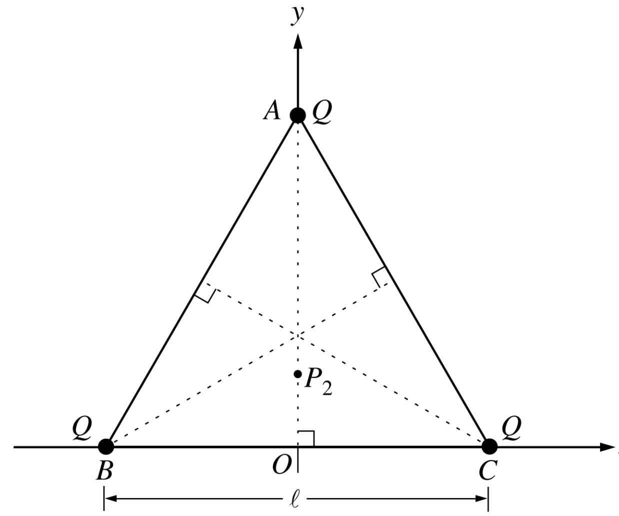


Figure 2

(a)

i. Point P_1, the intersection of the three bisectors, locates the geometric center of the triangle and is one point where the electric field is zero. On Figure 1 above, draw the electric field vectors $\mathbf{E}_A$, $\mathbf{E}_B$, and $\mathbf{E}_C$ at P_1 due to each of the three charges. Be sure your arrows are drawn to reflect the relative magnitude of the fields.

ii. Another point where the electric field is zero is point P_2 at $(0,\ y_2)$. On Figure 2 above, draw electric field vectors $\mathbf{E}_A$, $\mathbf{E}_B$, and $\mathbf{E}_C$ at P_2 due to each of the three point charges. Indicate below whether the magnitude of each of these vectors is greater than, less than, or the same as for point P_1.

	Greater than at P_1	Less than at P_1	The same as at P_1
E_A			
E_B			
E_C			

2000 Physics C Solutions | **Distribution of points**

E&M. 1 (15 points)

(a) 4 points

Since brightness is proportional to the power dissipated by a bulb, the answer may be found by solving the circuit to determine the power dissipated by each bulb. For example,

$$\frac{1}{R_p} = \frac{1}{12\ \Omega} + \frac{1}{6\ \Omega} = \frac{3}{12\ \Omega}$$, where R_p is the resistance of the parallel combination of resistors

$$R_p = 4\Omega$$

$$I_A = \frac{\mathcal{E}}{R_A + R_p} = \frac{42\ \text{V}}{10\ \Omega + 4\ \Omega} = 3\ \text{A}$$

$$I_B = \frac{V_p}{R_B} = \frac{I_A R_p}{R_B} = \frac{(3\ \text{A})(4\ \Omega)}{12\ \Omega} = 1\ \text{A}$$

$$I_C = \frac{V_p}{R_C} = \frac{I_A R_p}{R_C} = \frac{3 \cdot 4(3\ \text{A})(4\ \Omega)}{6\ \Omega} = 2\ \text{A}$$

$$P_A = I_A{}^2 R_A = (3\ \text{A})^2 (10\ \Omega) = 90\ \text{W}$$

$$P_B = I_B{}^2 R_B = (1\ \text{A})^2 (12\ \Omega) = 12\ \text{W}$$

$$P_C = I_C{}^2 R_C = (2\ \text{A})^2 (6\ \Omega) = 24\ \text{W}$$

For correct ordering, i.e., bulb *A* is brighter than bulb *C*, which is brighter than bulb *B* — 3 points

(Partial credit of 1 point given for incorrect answer but with an indication that bulb *A* is brightest or that bulb *C* is brighter than bulb *B*.)

For a correct explanation, which can be by a quantitative solution for the currents and powers as above, or by a qualitative approach that notes that all the current in the circuit flows through bulb *A*, then branches in such a way that bulb *C* receives more current than bulb *B*. — 1 point

(b)

i. 3 points

Immediately after the switch is closed there is no current in the inductor so the circuit consists of resistors *A* and *B* in series with the source of emf.

For $I_C = 0$ — 1 point

For recognition that $I_A = I_B$ and they are nonzero — 1 point

For correct numerical answers for I_A and I_B, i.e., $I_A = I_B = \dfrac{42\ \text{V}}{10\ \Omega + 12\ \Omega} = 1.91\ \text{A}$ — 1 point