AP Physics C: Electricity and Magnetism
2000 Student Samples

These materials were produced by Educational Testing Service (ETS), which develops and administers the examinations of the Advanced Placement Program for the College Board. The College Board and Educational Testing Service (ETS) are dedicated to the principle of equal opportunity, and their programs, services, and employment policies are guided by that principle.

The College Board is a national nonprofit membership association dedicated to preparing, inspiring, and connecting students to college and opportunity. Founded in 1900, the association is composed of more than 3,900 schools, colleges, universities, and other educational organizations. Each year, the College Board serves over three million students and their parents, 22,000 high schools, and 3,500 colleges, through major programs and services in college admission, guidance, assessment, financial aid, enrollment, and teaching and learning. Among its best-known programs are the SAT®, the PSAT/NMSQT™, the Advanced Placement Program® (AP®), and Pacesetter®. The College Board is committed to the principles of equity and excellence, and that commitment is embodied in all of its programs, services, activities, and concerns.

E E E E E E E E E E E E E E E E E E E E

Q1

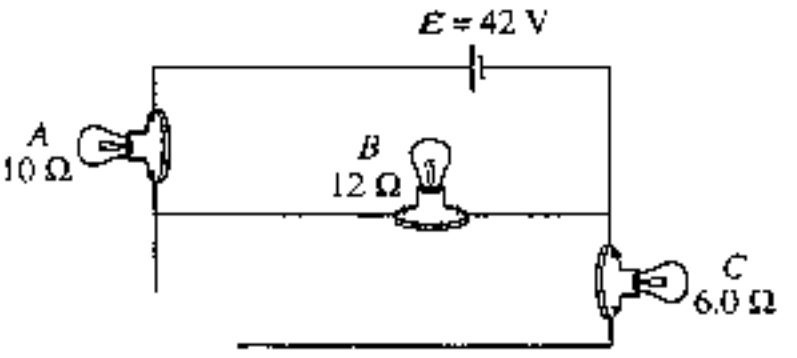
PHYSICS C

Section II, ELECTRICITY AND MAGNETISM

Time—45 minutes

3 Questions

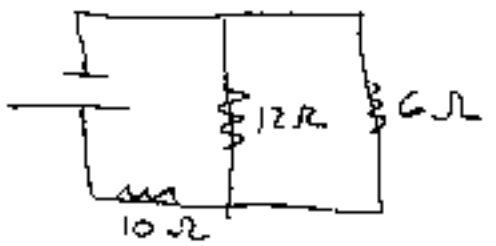
Directions: Answer all three questions. The suggested time is about 15 minutes for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part, NOT in the green insert.



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.



	V	I	R
A	30 V	3 A	10 Ω
B	12 V	1 A	12 Ω
C	12V	2 A	6 Ω
tot	42V	3 A	14 Ω

$P = IV$

$P_A = 3(30) = 90\ W$

$P_B = 1(12) = 12\ W$

$P_C = 2(12) = 24\ W$

Brightest = A

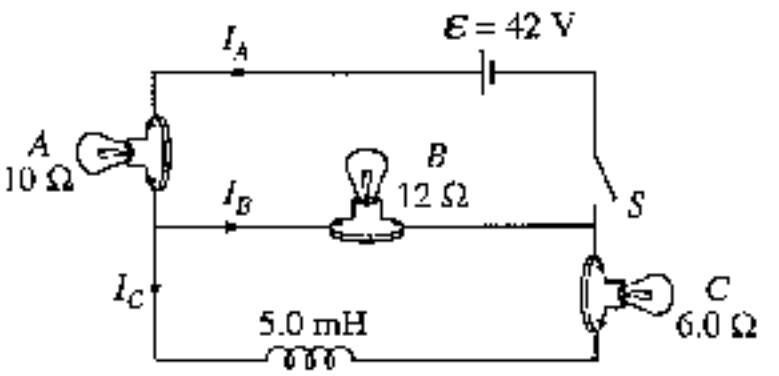
Next = C

Least = B

GO ON TO THE NEXT PAGE.

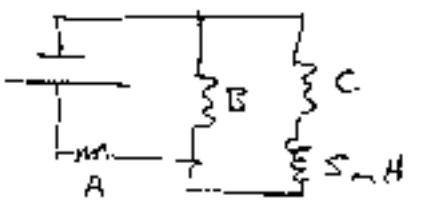
E E E E E E E E E E E E E E E E E

Q2



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

Current through the inductor = 0

$I_A = 1.91$ A

$I_B = 1.91$ A

$I_C = 0$ A

$R_{eq} = 22\ \Omega$

$42 = IR$

$I = \frac{42}{22} = 1.91$ A

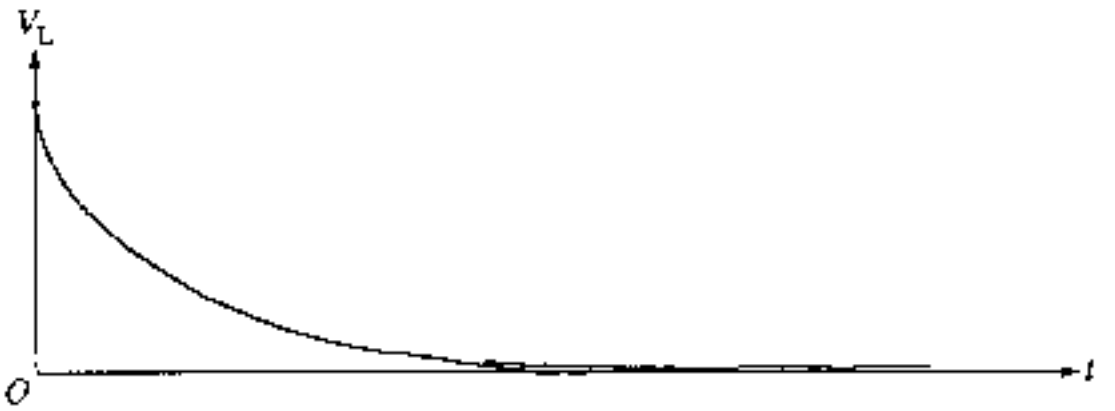
ii. A long time after the switch is closed

$I_A = 3$ A

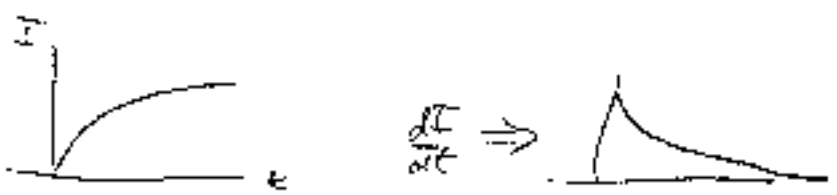
$I_B = 1$ A

$I_C = 2$ A

(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.

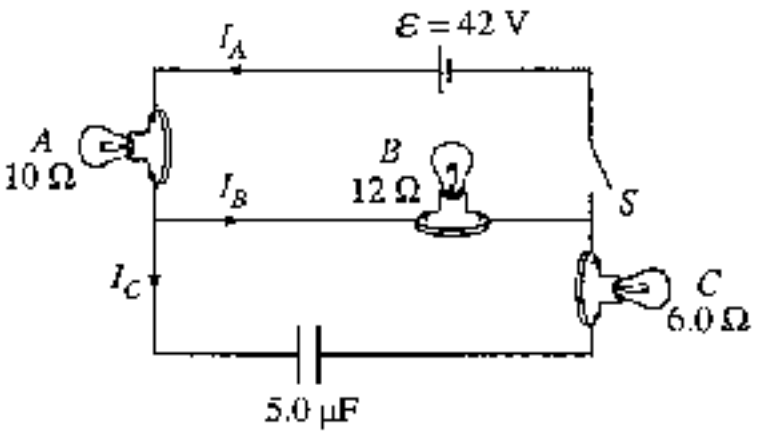


$V_L = L\frac{dI}{dt}$

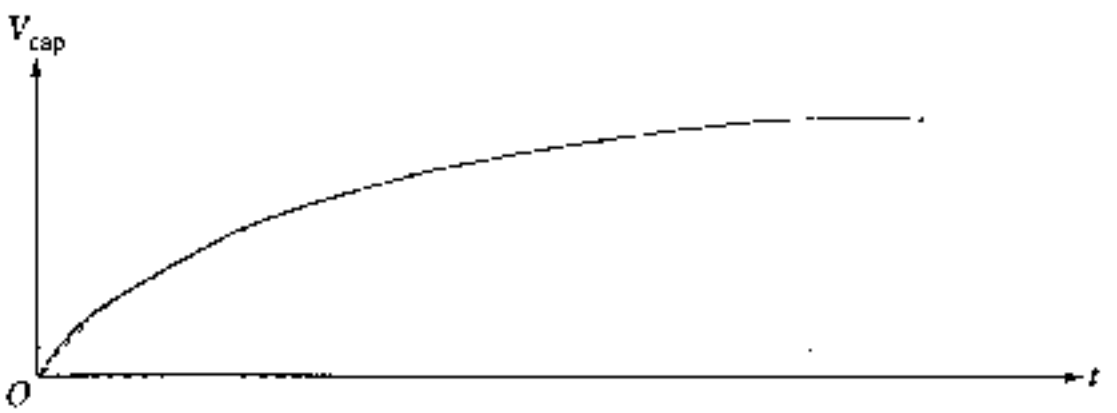


GO ON TO THE NEXT PAGE.

E E E E E E E E E E E E E E E E Q3



(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.



$V = \frac{Q}{C}$; $C = 5.0\ \mu F$

Q starts @ 0; goes to some constant value

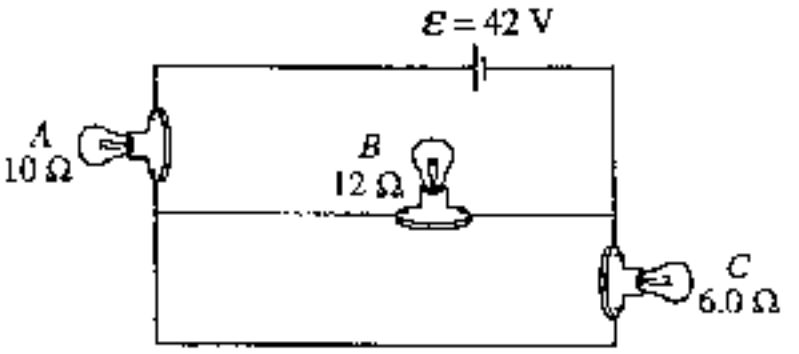
GO ON TO THE NEXT PAGE.

E E E E E E E E E E E E E E E E E R1

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 this booklet in the spaces provided after each part, NOT in the 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.

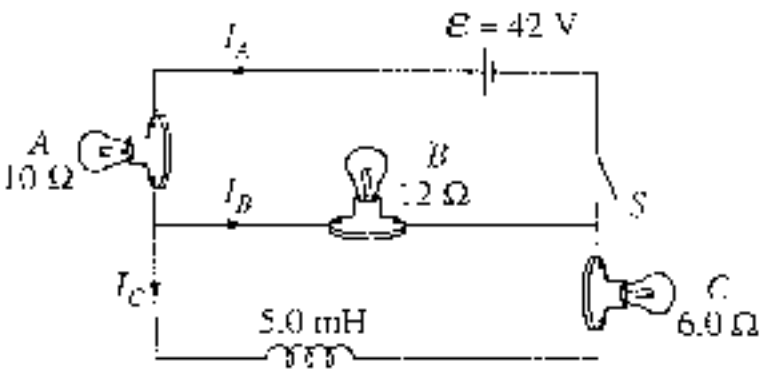
$P = I^2R$

Lightbulb A has the brightest light, because all current must run through it so it has the greatest I, and ∴ the most power

Lightbulb C is the second brightest since it has less resistance than Lightbulb B, which means more current and ∴ more power according to $P = I^2R$

Lightbulb B has the least brightness, because it has the least current pass through it.

E E E E E E E E E E E E E E E E R2

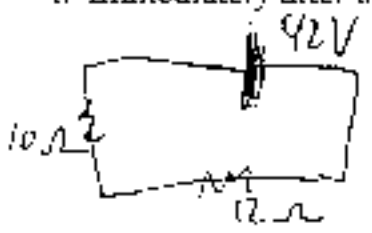


Now a switch S and a 5.0 mH inductor are added to the circuit, as shown above. The switch is closed at time $t = 0$.

$I = I_{max}(1 - e^{-(t/\tau)})$

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

i. Immediately after the switch is closed



$V = IR$

$42V = I_A(22\Omega)$

$I_A = 1.9\,A$

$V = I_B R$

$42V = I_B(22\Omega)$

$I_B = 1.9A$

$I = I_{max}(1 - e^{-\frac{t}{\tau}})$

$I_L = I_{max}(1 - 1)$

$I_L = 0A$

ii. A long time after the switch is closed

$V = I_A R$

$42V = I_A(14\Omega)$

$I_A = 3A$

$R = 10\Omega + \left(\frac{1}{12} + \frac{1}{6}\right)^{-1} = 14\Omega$

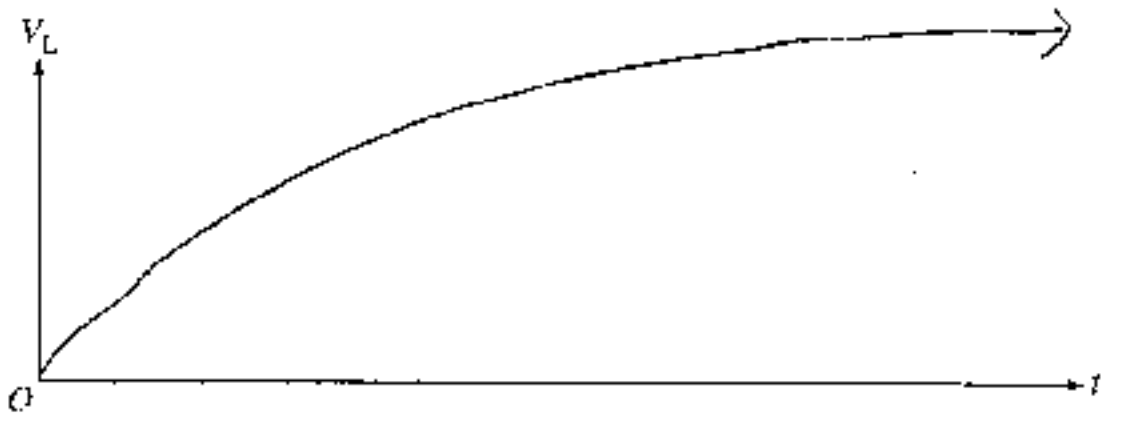
$I_B = 3A\left(\frac{6}{12+6}\right)$

$I_B = 3\left(\frac{6}{18}\right)$ $I_B = 1A$

$3A - 1A = I_C$

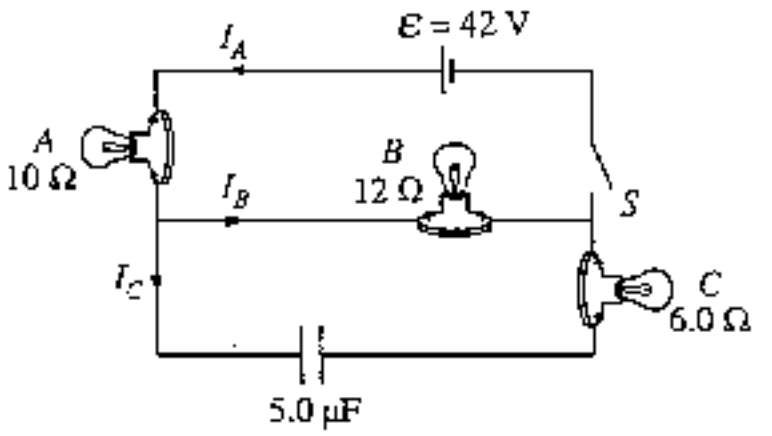
$I_C = 2A$

(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.

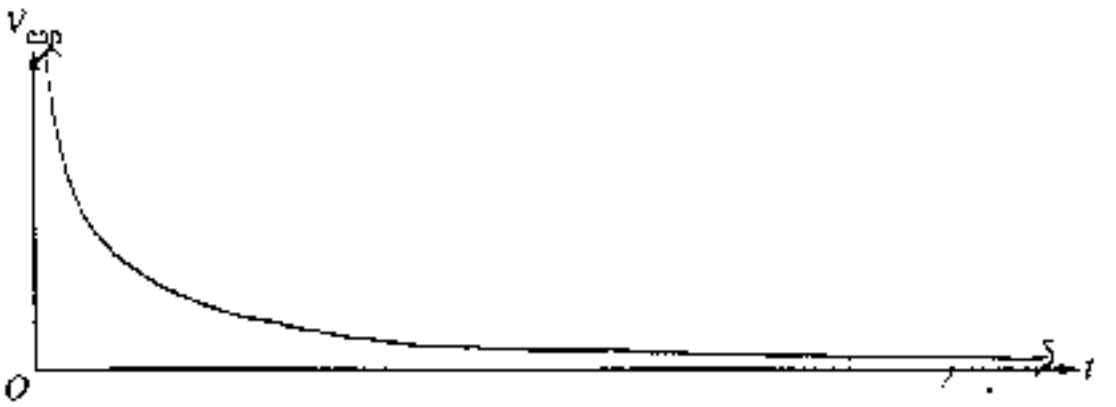


GO ON TO THE NEXT PAGE.

E E E E E E E E E E E E E E E E R3



(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.



GO ON TO THE NEXT PAGE.

E E E E E E E E E E E E E E E E E S1

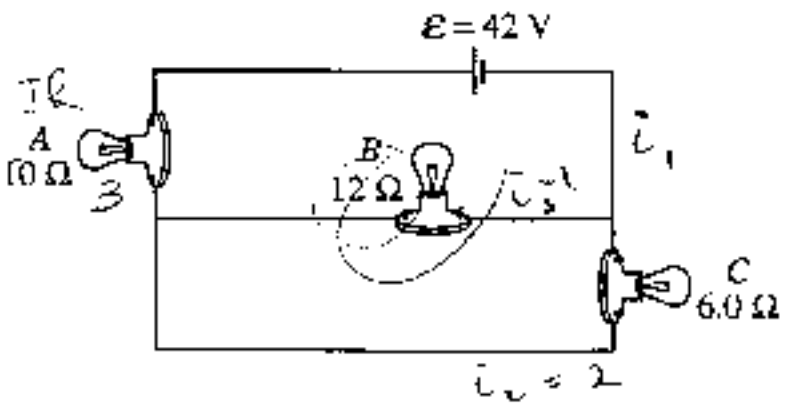
PHYSICS C

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 this booklet in the spaces provided after each part, NOT in the 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.

$$\frac{1}{R_{BC}} = \frac{1}{12\Omega} + \frac{1}{16\Omega}$$

$$R_{BC} = 4\Omega$$

$$R_{BC} < R_A, \; R_C < R_B$$

Therefore:

Brightest A $i = \frac{42}{10+4} = 3$ amp

C $i = \frac{12}{6} = 2$ amp

Least Bright B $i = \frac{12}{12} = 1$ amp

$$\mathcal{E} - 10i - 4i = 0$$

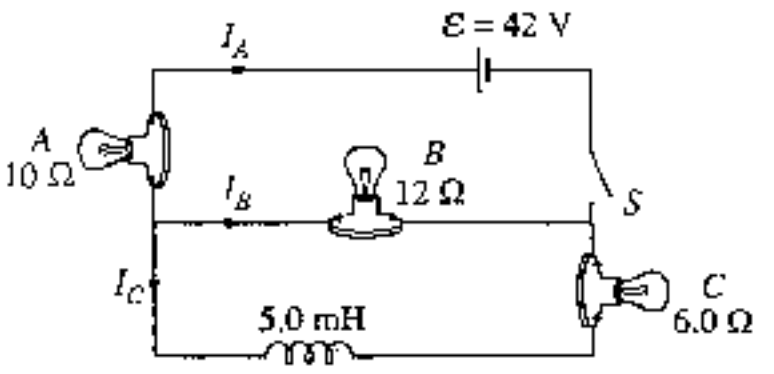
$$42 = 14i$$

$$i_1 = 3 \text{ amp}$$

$V_{BC} = 42 - 10(3) = 12$ V

since $V = IR$, and V is constant between B and C. Lower R means lower I and lower brightness.

A has higher R, but also higher V



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

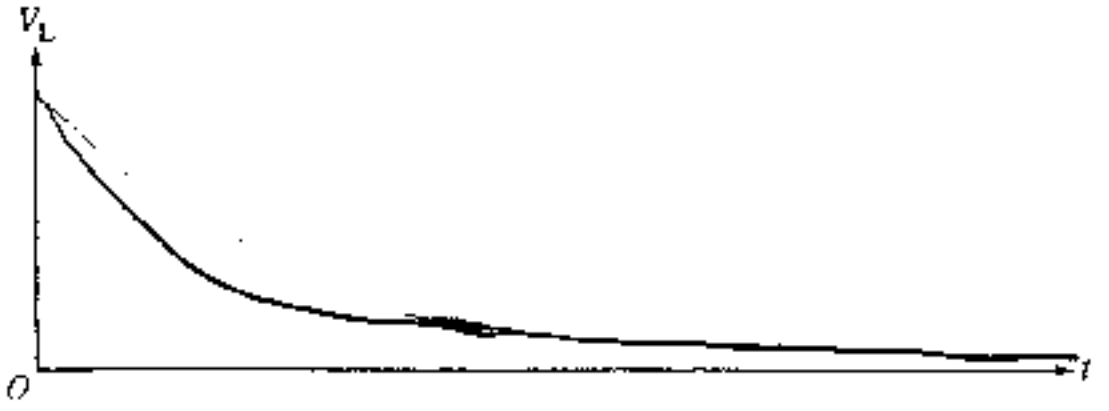
(b) Determine the currents I_A, I_B, and I_C for the following times.

i. Immediately after the switch is closed

$I_A = I_B = \frac{V}{R} = \frac{42}{10+12} = 1.9$ amp

ii. A long time after the switch is closed

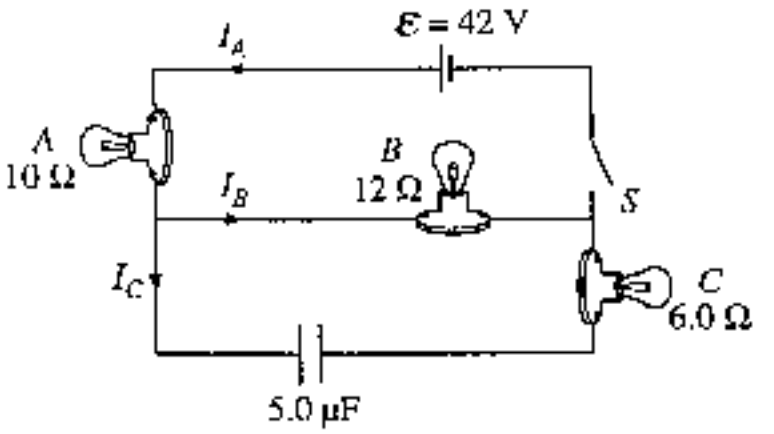
(c) On the axes below, sketch the magnitude of the potential difference V_L across the inductor as a function of time, from immediately after the switch is closed until a long time after the switch is closed.



$\mathcal{E} = -L\frac{dI}{dt}$

1

E E E E E E E E E E E E E E E E E 53



(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.