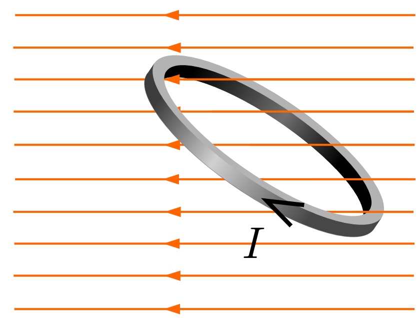
University Physics 2
Midterm Exam 2

Name: ___*Solutions*___

Multiple Choice Questions:

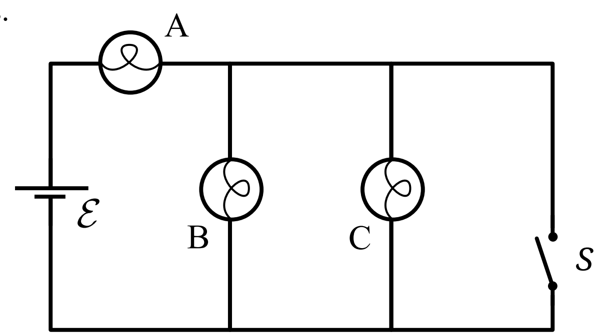
Select the best answer by circling the letter.

1. A current flows in the circular loop shown. There is a uniform magnetic field to the left. What will happen to the loop?



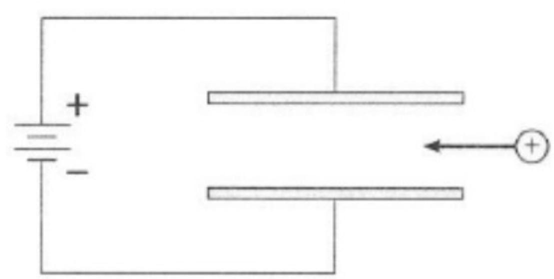
   a. the loop rotates clockwise
   b. the loop rotates counterclockwise
   c. the loop translates toward the right
   d. the loop does not move

2. The circuit shown is made with three identical bulbs. What happens when the switch is closed?



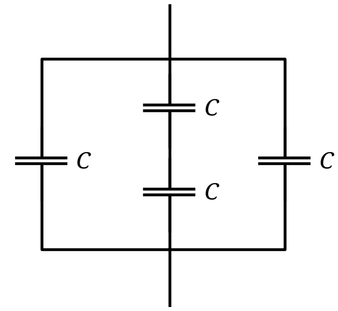
   a. A gets brighter, B gets dimmer, C turns on
   b. A gets brighter, B and C turn off
   c. A gets dimmer, B gets brighter, C turns on
   d. A and B get brighter, C turns on

3. When a positive ion flies between the plates of a parallel-plate capacitor, it will be deflected from its original path. Suppose you wanted to prevent the deflection, so the ion traveled straight through. How could you direct a magnetic field to do this?



   a. magnetic field points into the page
   b. magnetic field points to the left
   c. magnetic field points out of the page
   d. magnetic field points to the right

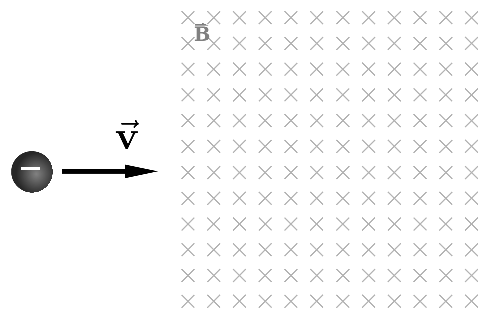
4. Each capacitor in the network shown at the right has capacitance C. What is the equivalent capacitance of this group?



a. $\frac{2}{5}C$ b. C

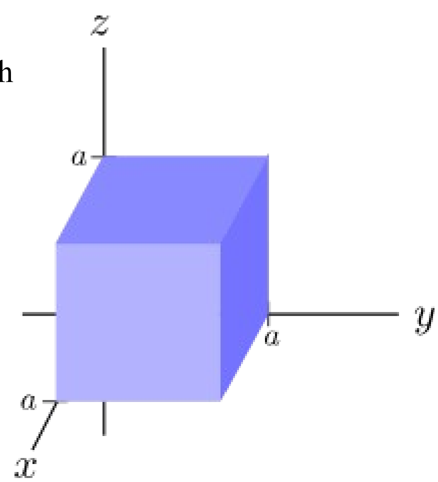
c. $\frac{5}{2}C$ d. $4C$

5. A negative charge enters a magnetic field as shown. In what direction will the initial magnetic force on the charge be?



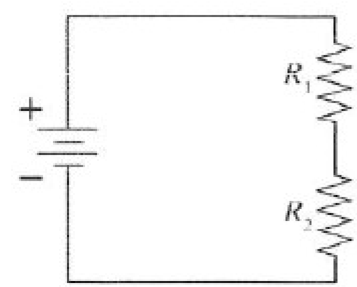
a. up b. down
c. in d. out

6. A current flows in the $+x$ through the conducting cube shown, with side length a. A uniform magnetic field is present, which points in the $+y$ direction. How would charge accumulate on this cube?



a. positive charge on the $y = a$ face
b. positive charge on the $z = a$ face
c. negative charge on the $y = a$ face
b. negative charge on the $z = a$ face

7. In the circuit shown, $R_1 > R_2$.
Which resistor dissipates the larger amount of power?



a. R_1

b. R_2

c. the same power

8. An electron is moving along the x-axis in the $+x$ direction. When the particle passes the origin, the direction of the magnetic field at point $\vec{r} = \langle 0, 0, 1 \rangle$ m is in the direction of which vector?

a. $-\hat{\imath}$ b. $-\hat{\jmath}$ c. $\hat{k}$ d. zero magnetic field

Long Answer Problems:

Correct units must be included with every answer.

Give vector answers in $\hat{\imath}\ \hat{\jmath}\ \hat{k}$ notation.

Answers should be written on the blank provided, and work that you want credit for must be done in the box. If you need more space, indicate in writing that the work is continued in another area.

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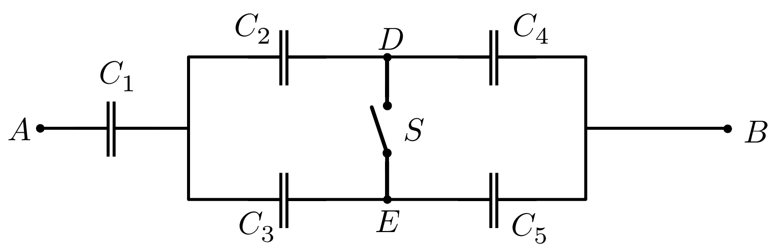
1. A 100 V potential is maintained between points *A* and *B* in the network shown. The capacitance values are

$C_1 = 1.0\ \mu\text{F}$
$C_2 = 2.0\ \mu\text{F}$
$C_3 = 3.0\ \mu\text{F}$
$C_4 = 4.0\ \mu\text{F}$
$C_5 = 5.0\ \mu\text{F}$



Determine the voltage between points *D* and *E* when the switch is open.

answer: $V =$ 0.99 V (E at higher voltage)

$C_{24} = \left(\frac{1}{C_2} + \frac{1}{C_4}\right)^{-1} = 1.33\ \mu\text{F}$

$C_{35} = \left(\frac{1}{C_3} + \frac{1}{C_5}\right)^{-1} = 1.88\ \mu\text{F}$

$C_p = C_{24} + C_{35} = 3.21\ \mu\text{F}$

$C_T = \left(\frac{1}{C_1} + \frac{1}{C_p}\right)^{-1} = 0.762\ \mu\text{F}$

total charge stored: $Q_T = C_T V = 76.2\ \mu\text{C}$

voltage on C_1: $V_1 = \frac{Q_1}{C_1} = \frac{Q_T}{C_1} = 76.2\ \text{V}$

voltage on $C_2 + C_4$: $V_{24} = 100\ \text{V} - V_1 = 23.76\ \text{V}$

charge on C_2 and C_4: $Q_2 = Q_4 = C_{24} V_{24} = 31.63\ \mu\text{C}$

$V_2 = \frac{Q_2}{C_2} = 15.84\ \text{V}$ $\quad V_4 = \frac{Q_4}{C_4} = 7.92\ \text{V} = V_{DB}$

$V_{DB} = 7.92\ \text{V}$

charge on C_3 and C_5: $Q_3 = Q_5 = C_{35} V_{35} = 44.55\ \mu\text{C}$ ($V_{35} = V_{24}$)

$V_5 = \frac{Q_5}{C_5} = 8.91\ \text{V} = V_{EB}$

$V_{DE} = V_{DB} - V_{EB} = -0.99\ \text{V}$

2. A wire of length 50 cm is formed into a single-turn square loop. The loop carries a current of 1.0 A, and it is placed in a uniform magnetic field of strength 0.01 T.

   What is the maximum torque that the loop will experience while in the magnetic field?

   answer: $\tau =$ 1.56×10^{-4} N·m

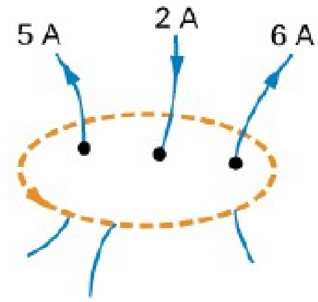
$l = 0.5$ m   area $A = \left(\frac{l}{4}\right)^2$

$\mu = IA = \frac{Il^2}{16}$

$\vec{\tau} = \vec{\mu} \times \vec{B}$

max $\tau = \mu B = \frac{Il^2}{16} \cdot B = 1.56 \times 10^{-4}$ N·m

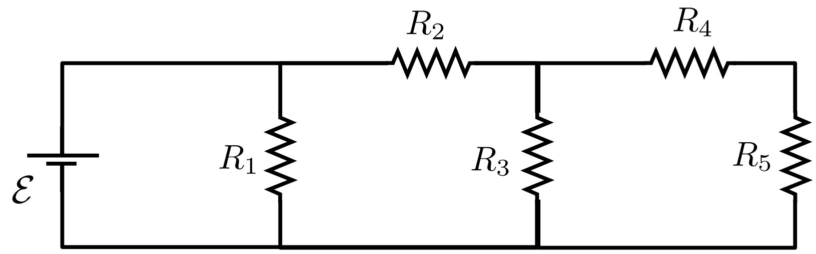
3. Determine $\oint \vec{B} \cdot d\vec{\ell}$ for a path along the dotted line shown.



answer: $(9A)\mu_0 = 1.13 \times 10^{-5}$ T·m

$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{thru} = \mu_0 (5 - 2 + 6) = 9\mu_0$$

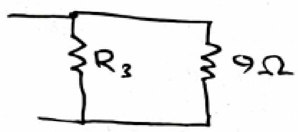
4. What current flows through the battery in the circuit shown?



Values are

$R_1 = 1\,\Omega$
$R_2 = 2\,\Omega$
$R_3 = 3\,\Omega$
$R_4 = 4\,\Omega$
$R_5 = 5\,\Omega$
$\mathcal{E} = 1\,\text{V}$

answer: $I =$ 1.235 A



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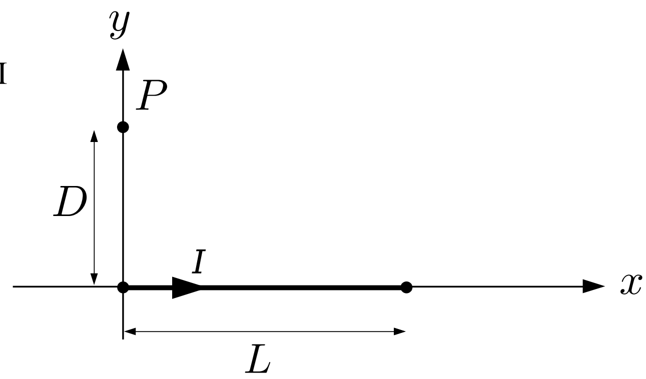
$$R_{35} = \left(\frac{1}{3} + \frac{1}{9}\right)^{-1} = 2.25\,\Omega$$

$$R_{25} = R_2 + R_{35} = 4.25\,\Omega$$

$$R_T = \left(\frac{1}{R_1} + \frac{1}{R_{25}}\right)^{-1} = 0.810\,\Omega$$

$$I = \frac{\mathcal{E}}{R_T} = 1.235\text{ A}$$

5. Suppose you need to find the magnetic field at point *P* due to the wire segment carrying current I between the origin and a point a distance *L* away, as shown.



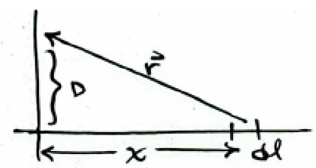
Set up and simplify the integral required to solve this problem – you do not need to evaluate the integral.

A fully simplified answer should

- be written in terms of the variables shown (and fundamental constants)
- be an integral (with limits) over a single variable
- have all constants out of the integral
- include $\hat{\imath}\ \hat{\jmath}\ \hat{k}$ (as necessary) for the vector direction

answer: $\vec{B} = \frac{\mu_0 I D}{4\pi} \hat{k} \int_0^L (x^2 + D^2)^{-3/2} dx$

$$\vec{B} = \int d\vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{\ell} \times \vec{r}}{r^3}$$



$$\left.\begin{aligned} \vec{r} &= -x\hat{\imath} + D\hat{\jmath} \\ d\vec{\ell} &= \hat{\imath}\, dx \end{aligned}\right\} d\vec{\ell} \times \vec{r} = (D\,dx)\hat{k}$$

$$r^3 = (x^2 + D^2)^{3/2}$$

$$\vec{B} = \frac{\mu_0 I}{4\pi} D \hat{k} \int_0^L \frac{dx}{(x^2 + D^2)^{3/2}}$$