SP212 Exam #4

Name and Alpha: Version A

1. A −2.5 mC point charge has $K_i = 1.8$ J of kinetic energy when it is located at a position with an electric potential of $V_i = +250$ V. What will its kinetic energy be once it has moved to a position with an electric potential of $V_f = +50$ V?

   A. 1.70 J

   B. 1.90 J

   C. 1.30 J

   D. 1.50 J

   E. 2.10 J

$K_i + U_i = K_f + U_f \qquad U = qV$

$1.8\,\text{J} + (-2.5\times10^{-3}\,\text{C})(250\,\text{V}) = K_f + (-2.5\times10^{-3}\,\text{C})(50\,\text{V})$

$K_f = 1.30\,\text{J}$

2. What is the equivalent resistance between the ends of this resistor network?

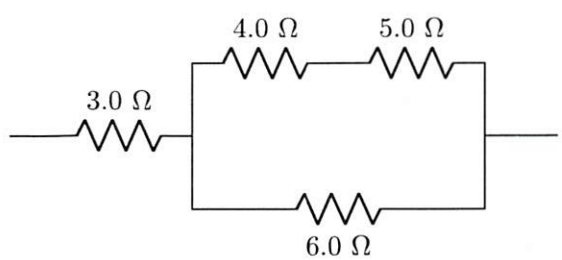
   A. 2.50 Ω

   B. 2.20 Ω

   C. 6.60 Ω

   D. 4.62 Ω

   E. 18.0 Ω



4 & 5 in series: $4\,\Omega + 5\,\Omega = 9\,\Omega$

9 & 6 in parallel: $\left(\frac{1}{9\,\Omega} + \frac{1}{6\,\Omega}\right)^{-1} = 3.6\,\Omega$

3 & 3.6 in series: $3\,\Omega + 3.6\,\Omega = 6.6\,\Omega$

3. A circular wire loop with 25 turns and a radius of 0.15 m lies in the xy plane. A current of 3.4 A flows through this loop, counter-clockwise when viewed from above. A magnetic field of magnitude 0.17 T makes an angle of 35° with the z-axis. What is the magnitude of the torque acting on the loop at this moment?

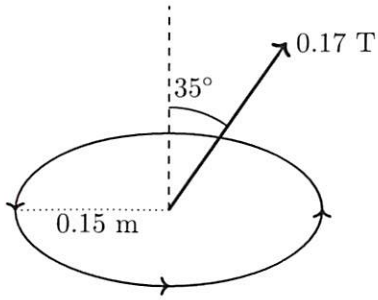
A. 0.715 N·m

B. 0.586 N·m

C. 1.23×10^{-7} N·m

D. 0.837 N·m

E. 1.02 N·m



$\mu = NIA = 25\,(3.4\,A)\,\pi\,(.15\,m)^2 = 6.0083\ A\cdot m^2$

$\vec{\tau} = \vec{\mu} \times \vec{B} \qquad \tau = \mu B \sin\theta$

$\tau = (6.0083\ A\cdot m)^2\,(0.17\,T)\sin 35° = 0.586\ N\cdot m$

4. A point particle with charge $+3.6 \times 10^{-3}$ C is moving with velocity $(750\text{ m/s})\hat{\imath}$ when it passes through the origin. What is the magnitude of the magnetic field at point P, which is 0.25 m away from the particle in a direction 30° above the x-axis?

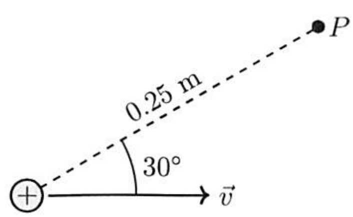
A. 4.32 μT

B. 0.540 μT

C. 2.16 μT

D. 2.49 μT

E. 3.74 μT



$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2} \qquad B = \frac{\mu_0}{4\pi}\frac{|q|\,v\sin\theta}{r^2}$

$(1\times10^{-7}\ T\cdot m/A)\frac{(3.6\times10^{-3}\,C)(750\,m/s)\sin 30°}{(0.25\,m)^2} = 2.16\times10^{-6}\ T$

5. Two very long, straight wires are parallel and separated by 0.0080 m. The wire on the left carries a 4.0 A current up while the wire on the right carries a 5.0 A current down. A one-turn circular wire coil with a 0.0030 m radius lies between them, with its center at the midpoint between the two straight wires. This coil carries a 3.0 A current counter-clockwise. What is the magnitude of the net magnetic field at point P (the coil's center) due to these three currents?

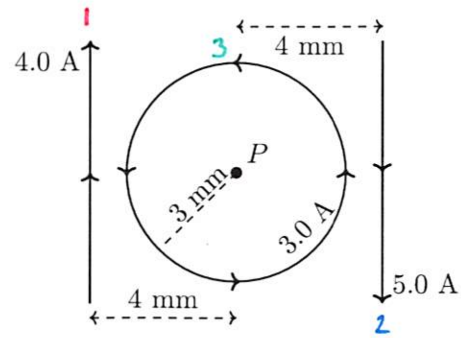
A. 0.271 mT

B. 0.220 mT

C. 0.198 mT

D. 0.178 mT

E. 0.244 mT



$$\#1: B_1 = \frac{\mu_0 I_1}{2\pi r} \quad \frac{\mu_0 (4.0\ A)}{2\pi\ (0.004\ m)} = 2.00\times10^{-4}\ T \quad \text{into the page}$$

$$\#2: B_2 = \frac{\mu_0 I_2}{2\pi r} \quad \frac{\mu_0 (5.0\ A)}{2\pi\ (.004\ m)} = 2.50\times10^{-4}\ T \quad \text{into the page}$$

$$B_{loop} = \frac{\mu_0}{4\pi}\frac{2\pi R^2 I}{(z^2+R^2)^{3/2}} \quad \text{when } z=0 \text{ this is } \frac{\mu_0 I_3}{2R}$$

$$\frac{\mu_0 (3.0\ A)}{2\ (0.003\ m)} = 6.283\times10^{-4}\ T \quad \text{out of the page}$$

$$B_{net} = (6.283\times10^{-4}\ T - 2.00\times10^{-4}\ T - 2.50\times10^{-4}\ T) = 1.78\times10^{-4}\ T$$

6. Two long, straight, parallel wires are separated by 0.015 m. The two wires carry the same current, but in opposite directions. There is a repulsive force on a 1.0 m length of each wire that has size 0.0046 N. What is the current passing through the wires?

A. 16.8 A

B. 20.6 A

C. 15.1 A

D. 13.6 A

E. 18.6 A

$$F = \frac{\mu_0 I_1 I_2}{2\pi r} \cdot \ell \qquad I_1 = I_2$$

$$0.0046\ N = \frac{\mu_0 I^2}{2\pi(.015\ m)}(1.0\ m)$$

$$I = 18.6\ A$$

7. The line integral $\oint_C \vec{B} \cdot d\vec{l}$ around the closed counter-clockwise Amperian loop shown below is $+3.0 \times 10^{-6}$ T·m. Three wires pass through this loop. Wire #1 carries 1.50 A into the page. Wire #2 carries 2.50 A out of the page. What is the current in the third wire?

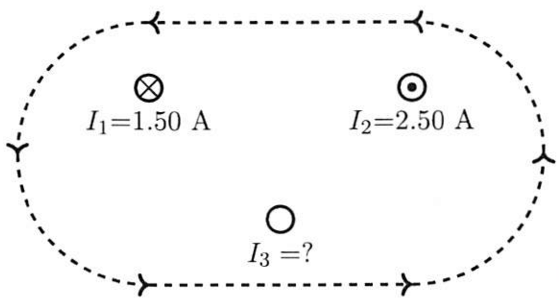
A. 1.39 A out of the page

B. 1.19 A into the page

C. 1.59 A into the page

D. 1.59 A out of the page

E. 1.79 A into the page



$$\oint_C \vec{B} \cdot d\vec{\ell} = \mu_0 I_c \quad \text{so} \quad I_c = \frac{3.0 \times 10^{-6}\ T \cdot m}{\mu_0} = 2.39\ A$$

ccw integration → ⊙ is positive current

$$(-1.50\ A) + (2.50\ A) + I_3 = +2.39\ A$$

$$I_3 = +1.39\ A$$

8. A wire loop has an area and normal unit vector given by $A\hat{n} = (0.46\hat{\imath} + 0.68\hat{\jmath})\,\mathrm{m}^2$. The loop is in a region with a uniform magnetic field given by $\vec{B} = (2.7\hat{\jmath} + 3.4\hat{k})\,\mathrm{T}$. How much magnetic flux passes through this loop?

A. 1.84 Wb

B. 3.83 Wb

C. 1.56 Wb

D. 3.36 Wb

E. 3.55 Wb

$\Phi_m = \int_S \vec{B} \cdot \hat{n}\, dA$

uniform $\vec{B}$, flat surface $\Phi_m = \vec{B} \cdot \hat{n} A$

$\Phi_m = (0T)(.46\,m^2) + (2.7T)(.68\,m^2) + (3.4T)(0\,m^2)$

$= 1.84$ Wb

9. A circular wire loop with a radius of 0.30 m lies in the plane of the page. There is a uniform magnetic field pointing out of the page. The magnetic field strength is increasing, given by $B_z(t) = (2.0\ \mathrm{T/s^2})t^2$. What is the magnitude of the induced emf in this loop at time $t = 1.5$ s?

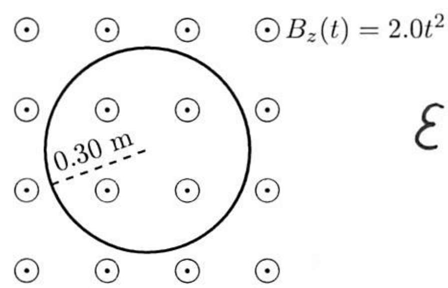
A. 1.48 V

B. 2.38 V

C. 2.13 V

D. 1.90 V

E. 1.70 V



$\mathcal{E} = -\frac{d\Phi_m}{dt}$

$|\mathcal{E}| = A \frac{dB}{dt}$ $\frac{dB}{dt} = 4t$

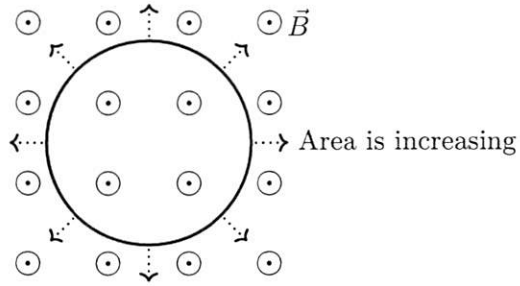
$\pi(0.30\,m)^2 * \left(4\frac{T}{s^2}\right)(1.5\,s) = 1.70$ V

10. A wire loop is placed in the plane of the page. There is a magnetic field directed out of the page. The wire loop is increasing in size. What is the direction of the induced emf in the loop?

A. Clockwise

B. Counter-clockwise

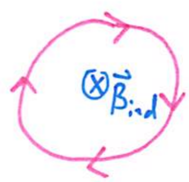
C. There is no induced emf



Area is increasing → Φ_m is increasing

Therefore $\vec{B}_{induced}$ is opposite $\vec{B}_{external}$

$\vec{B}_{ind}$ is ⊗ into the page



Clockwise currents create B-fields into the page.

SP212 Exam #4

Name and Alpha: Version B

1. A −2.5 mC point charge has $K_i = 2.2$ J of kinetic energy when it is located at a position with an electric potential of $V_i = +250$ V. What will its kinetic energy be once it has moved to a position with an electric potential of $V_f = +50$ V?

A. 1.50 J

B. 1.70 J

C. 1.90 J

D. 2.10 J

E. 1.30 J

$K_i + U_i = K_F + U_F$ $U = qV$

$2.2\text{ J} + (-2.5\times10^{-3}\text{C})(250\text{V}) = K_F + (-2.5\times10^{-3}\text{C})(50\text{V})$

$K_F = 1.70\text{ J}$

2. What is the equivalent resistance between the ends of this resistor network?

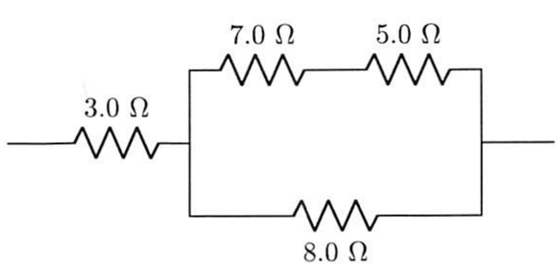
A. 7.80 Ω

B. 23.0 Ω

C. 2.35 Ω

D. 5.14 Ω

E. 13.9 Ω



7 $ 5 in series: $7\Omega + 5\Omega = 12\Omega$

12 $ 8 in parallel: $\left(\frac{1}{12\Omega} + \frac{1}{8\Omega}\right)^{-1} = 4.80\Omega$

3.0 $ 4.8 in series: $3.0\Omega + 4.8\Omega = 7.8\Omega$

3. A circular wire loop with 25 turns and a radius of 0.15 m lies in the xy plane. A current of 5.3 A flows through this loop, counter-clockwise when viewed from above. A magnetic field of magnitude 0.17 T makes an angle of 35° with the z-axis. What is the magnitude of the torque acting on the loop at this moment?

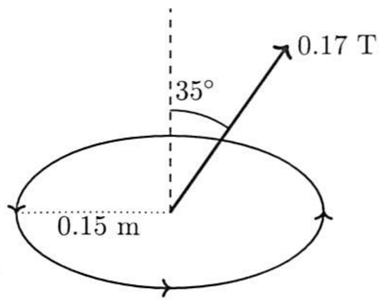
A. 0.913 N·m

B. 1.30 N·m

C. 1.23×10^{-7} N·m

D. 1.11 N·m

E. 1.59 N·m



$\mu = NIA \qquad \mu = 25(5.3\text{ A})\pi(0.15\text{ m})^2 = 9.366\text{ A}\cdot\text{m}^2$

$\vec{\tau} = \vec{\mu} \times \vec{B} \qquad \tau = \mu B \sin\theta$

$\tau = (9.366\text{ A}\cdot\text{m}^2)(0.17\text{ T}) \sin 35° = 0.913\text{ N}\cdot\text{m}$

4. A point particle with charge $+3.6 \times 10^{-3}$ C is moving with velocity (780 m/s)$\hat{\imath}$ when it passes through the origin. What is the magnitude of the magnetic field at point P, which is 0.25 m away from the particle in a direction 30° above the x-axis?

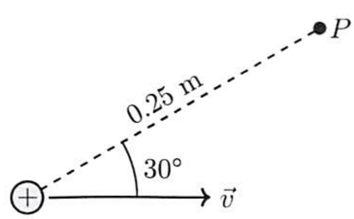
A. 2.59 μT

B. 2.25 μT

C. 4.49 μT

D. 0.562 μT

E. 3.89 μT



$\vec{B} = \frac{\mu_0}{4\pi} \frac{q\vec{v} \times \hat{r}}{r^2} \qquad B = \frac{\mu_0}{4\pi} \frac{|q| v \sin\theta}{r^2}$

$B = (1 \times 10^{-7}\ \frac{\text{T}\cdot\text{m}}{\text{A}}) \frac{(3.6 \times 10^{-3}\text{ C})(780\text{ m/s}) \sin 30°}{(0.25\text{ m})^2} = 2.25 \times 10^{-6}\text{ T}$

5. Two very long, straight wires are parallel and separated by 0.0080 m. The wire on the left carries a 5.0 A current up while the wire on the right carries a 6.0 A current down. A one-turn circular wire coil with a 0.0030 m radius lies between them, with its center at the midpoint between the two straight wires. This coil carries a 4.0 A current counter-clockwise. What is the magnitude of the net magnetic field at point P (the coil's center) due to these three currents?

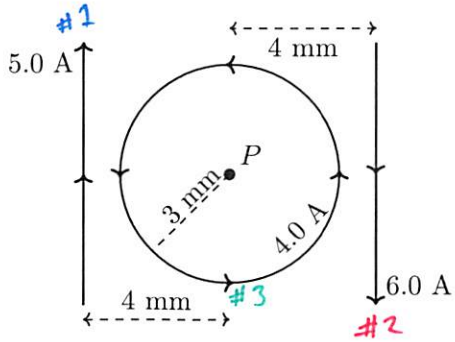
A. 0.319 mT

B. 0.288 mT

C. 0.394 mT

D. 0.437 mT

E. 0.355 mT



#1 $B = \frac{\mu_0 I_1}{2\pi r}$ $\quad \frac{\mu_0 (5.0\,A)}{2\pi(.004\,m)} = 2.500\times10^{-4}\,T$ into the page

#2 $B = \frac{\mu_0 I_2}{2\pi r}$ $\quad \frac{\mu_0 (6.0\,A)}{2\pi(.004\,m)} = 3.000\times10^{-4}\,T$ into the page

#3 $B_{loop} = \frac{\mu_0}{4\pi}\frac{2\pi R^2 I}{(z^2+R^2)^{3/2}}$ at center, $z = \varnothing$ so $B = \frac{\mu_0 I_3}{2R}$

$\frac{\mu_0 (4.0\,A)}{2(.003\,m)} = 8.378\times10^{-4}\,T$ out of the page

$B_{net} = (8.378\times10^{-4}\,T - 3.000\times10^{-4}\,T - 2.500\times10^{-4}\,T) = 2.88\times10^{-4}\,T$

6. Two long, straight, parallel wires are separated by 0.015 m. The two wires carry the same current, but in opposite directions. There is a repulsive force on a 1.0 m length of a wire that has size 0.0036 N. What is the current passing through the wires?

A. 16.4 A

B. 12.0 A

C. 18.2 A

D. 14.8 A

E. 13.3 A

$$F = \frac{\mu_0 I_1 I_2}{2\pi r} \ell \qquad I_1 = I_2 \text{ so } I_1 I_2 = I^2$$

$$0.0036\ N = \frac{\mu_0 I^2}{2\pi(.015\,m)}(1.0\,m)$$

$$I = 16.4\ A$$

7. The line integral $\oint_C \vec{B} \cdot d\vec{l}$ around the closed counter-clockwise Amperian loop shown below is $+3.3 \times 10^{-6}$ T·m. Three wires pass through this loop. Wire #1 carries 1.50 A into the page. Wire #2 carries 2.50 A out of the page. What is the current in the third wire?

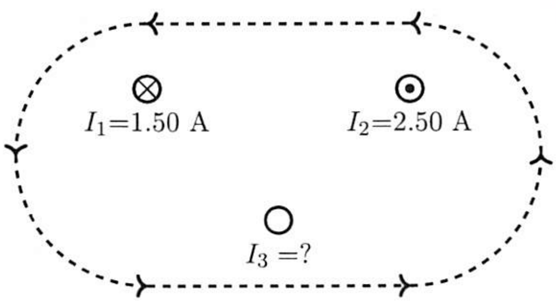
A. 1.43 A into the page

B. 1.43 A out of the page

C. 1.63 A out of the page

D. 1.23 A into the page

E. 1.83 A into the page



$$\oint_C \vec{B} \cdot d\vec{\ell} = \mu_0 I_c \qquad I_c = \frac{+3.3\times10^{-6}\ T\cdot m}{\mu_0} = +2.63\ A$$

counter-clockwise integration: out of the page ⊙ is positive

$$(-1.50\ A) + (+2.50\ A) + I_3 = +2.63\ A$$

$$I_3 = +1.63\ A$$

8. A wire loop has an area and normal unit vector given by $A\hat{n} = (0.46\hat{\imath} + 0.68\hat{\jmath})\,\text{m}^2$. The loop is in a region with a uniform magnetic field given by $\vec{B} = (3.4\hat{\jmath} + 2.7\hat{k})\,\text{T}$. How much magnetic flux passes through this loop?

A. 1.24 Wb

B. 3.56 Wb

C. 2.71 Wb

D. 3.40 Wb

E. 2.31 Wb

$\Phi_m = \int_S \vec{B} \cdot \hat{n}\, dA$ $\quad \Phi_m = \vec{B} \cdot \hat{n}\, dA$ for a uniform $\vec{B}$, flat surface

$(0.46\,\text{m}^2)(0\,\text{T}) + (0.68\,\text{m}^2)(3.4\,\text{T}) + (0\,\text{m}^2)(2.7\,\text{T})$

$= 2.31$ Wb

9. A circular wire loop with a radius of 0.28 m lies in the plane of the page. There is a uniform magnetic field pointing out of the page. The magnetic field strength is increasing, given by $B_z(t) = (2.0\ \text{T/s}^2)t^2$. What is the magnitude of the induced emf in this loop at time $t = 1.5$ s?

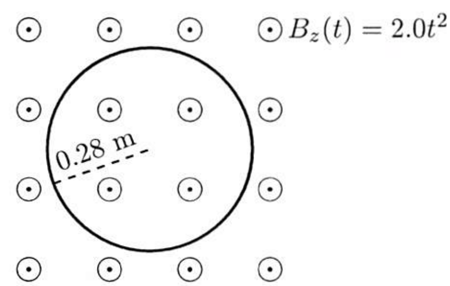
A. 1.70 V

B. 1.90 V

C. 1.48 V

D. 2.13 V

E. 2.38 V



$\mathcal{E} = -\frac{d\Phi_m}{dt}$ $\quad$ Field is changing

$|\mathcal{E}| = \frac{dB}{dt} A \cos 0°$ $\quad \frac{dB}{dt} = 4t$

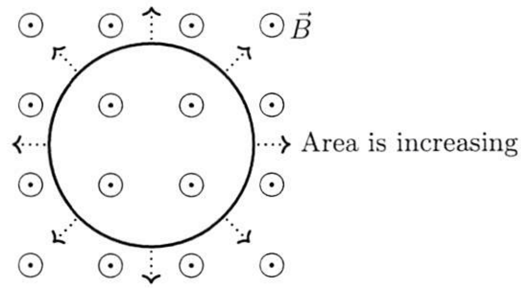
$|\mathcal{E}| = [4 \cdot 1.5]\,\pi(.28)^2 = 1.48\ \text{V}$

10. A wire loop is placed in the plane of the page. There is a magnetic field directed out of the page. The wire loop is increasing in size. What is the direction of the induced emf in the loop?

A. Clockwise

B. Counter-clockwise

C. There is no induced emf



Same as Version A