PHYS 102: General Physics 2 **KOÇ UNIVERSITY** **Spring Semester 2015**

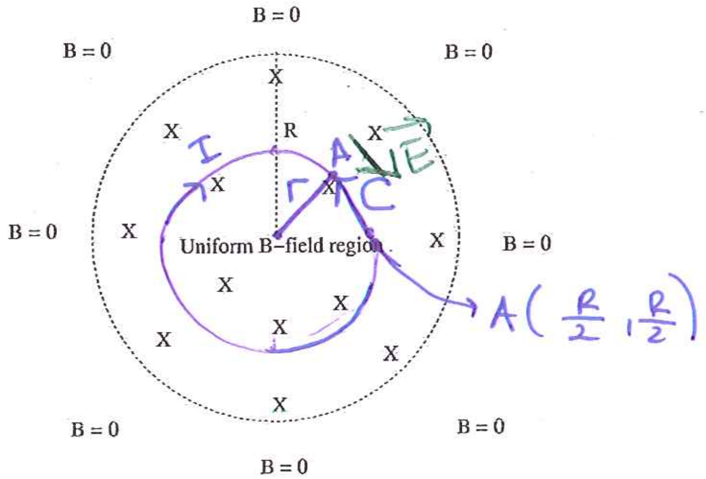
College of Sciences

Section 1 **Quiz 9** **07 May 2015**

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

The magnetic field B, at all points within a circular region of radius R, is uniform in space and directed into the plane of the page as shown in the figure. If the magnetic field is decreasing at a rate of dB/dt, find both the direction and the magnitude of the induced electric field at position $(x = R/2, y=R/2)$, defined from the center of the circular region.



$r = \frac{R}{\sqrt{2}}$

Induced $\vec{E}$ is always perpendicular to $\vec{B}$ $\Rightarrow \vec{E} \perp \vec{B}$ → on the paper plane

$$\oint_C \vec{E}\cdot d\vec{\ell} = -\frac{d\phi_B}{dt} \qquad \phi_B = \pi r^2 \cdot B$$

$$|\vec{E}|\cdot 2\pi r = \left|\frac{d\phi_B}{dt}\right| = \pi r^2 \cdot \left|\frac{dB}{dt}\right|$$

$$\Rightarrow |\vec{E}| = \frac{r}{2}\left|\frac{dB}{dt}\right| = \frac{R}{2\sqrt{2}}\left|\frac{dB}{dt}\right|$$

Induced current must increase B, so I is clockwise, and has same direction with $\vec{E}$ at every point.

$$\vec{E} = \frac{R}{2\sqrt{2}}\left|\frac{dB}{dt}\right|\cdot\frac{1}{\sqrt{2}}(i - j) = \frac{R}{4}\left|\frac{dB}{dt}\right|(\hat{i} - \hat{j})$$

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Section 2 | Quiz 9 | 07 May 2015

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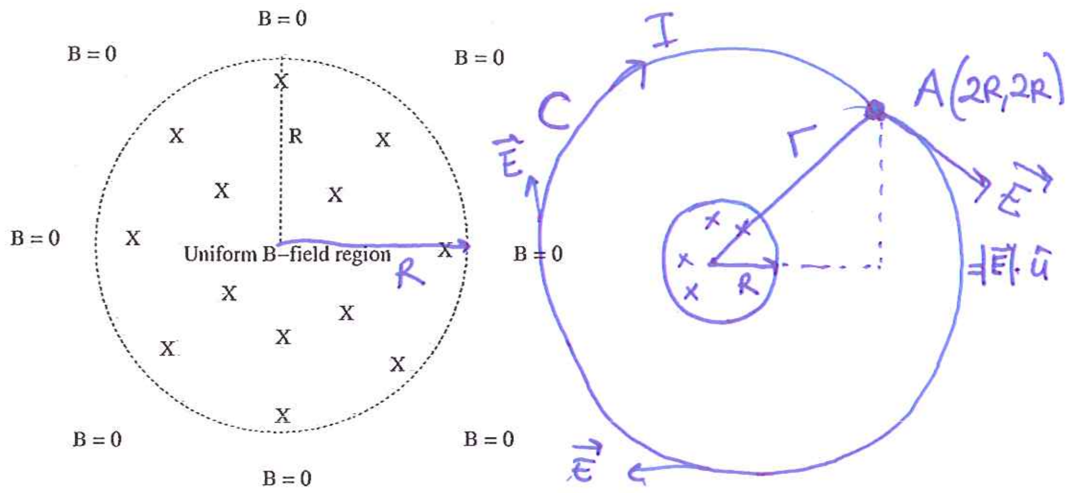
Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

The magnetic field *B*, at all points within a circular region of radius *R*, is uniform in space and directed into the plane of the page as shown in the figure. If the magnetic field is decreasing at a rate of *dB/dt*, find both the direction and the magnitude of the induced electric field at position *(x = 2R, y=2R)*, defined from the center of the circular region.



$r = 2\sqrt{2}\cdot R$

Induced $\vec{E}$ is on the plane since $\vec{E} \perp \vec{B}$.

$$\oint_C \vec{E}\cdot d\vec{\ell} = -\frac{d\Phi_B}{dt} \qquad \Phi_B = \pi R^2 \cdot B$$

$$\Rightarrow |\vec{E}|\cdot 2\pi r = \left| -\frac{d}{dt}\left(\pi R^2 \cdot B\right)\right| = \left| -\pi R^2 \cdot \frac{dB}{dt}\right| = \pi R^2 \cdot \left|\frac{dB}{dt}\right|$$

$$|\vec{E}| = \frac{R^2}{2r}\cdot\left|\frac{dB}{dt}\right| = \frac{R}{4\sqrt{2}}\left|\frac{dB}{dt}\right|$$

Induced current is in clockwise direction to increase $\vec{B}$.
$\vec{E}$ is tangential to path C, and parallel to I at any point.

$$\Rightarrow \vec{E} = \frac{R}{4\sqrt{2}}\cdot\left|\frac{dB}{dt}\right|\cdot\overbrace{\frac{1}{\sqrt{2}}(\hat{i}-\hat{j})}^{\hat{u}} = \frac{R}{8}\left|\frac{dB}{dt}\right|(\hat{i}-\hat{j})$$

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Section 3 | **Quiz 9** | **07 May 2015**

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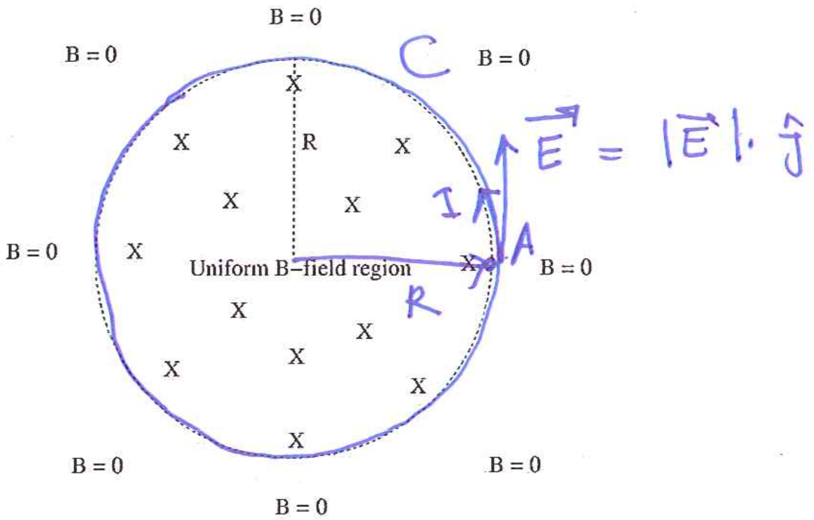
Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

The magnetic field B, at all points within a circular region of radius R, is uniform in space and directed into the plane of the page as shown in the figure. If the magnetic field is increasing with time t as $B = C\,t$, where C is a constant, find both the direction and the magnitude of the induced electric field at position $(x = R, y=0)$, defined from the center of the circular region.



Induced $\vec{E}$ is on the paper plane since $\vec{E} \perp \vec{B}$

$$\oint_C \vec{E} \cdot d\vec{\ell} = -\frac{d\Phi_B}{dt} = -\frac{d}{dt}\left(\pi R^2 \cdot B\right) = -\pi R^2 \cdot \frac{dB}{dt} = -\pi R^2 \cdot C$$

$$\Rightarrow |\vec{E}| \cdot 2\pi R = \pi R^2 \cdot C \quad \Rightarrow |\vec{E}| = \frac{C \cdot R}{2}$$

To decrease $\vec{B}$, induced current I is counter clockwise direction and parallel to $\vec{E}$ at any point.

$$\rightarrow \vec{E} = \frac{C \cdot R}{2} \cdot \hat{j}$$

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Section 4 | Quiz 9 | 07 May 2015

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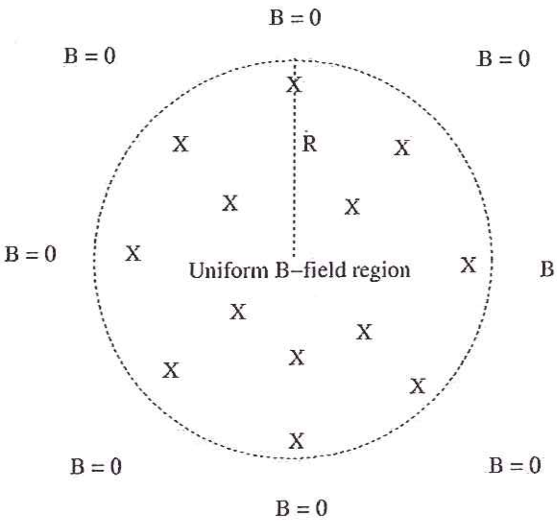
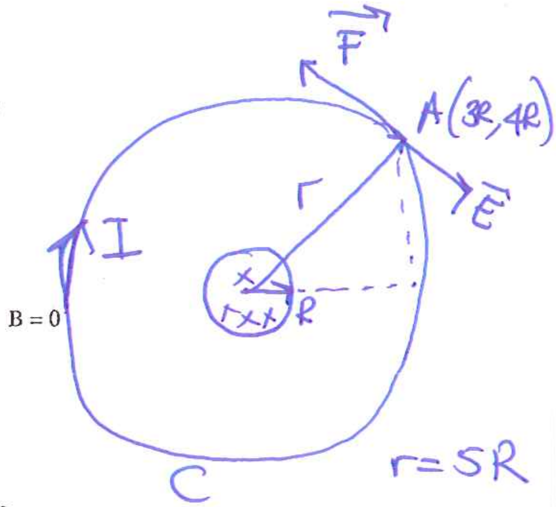
Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

The magnetic field B, at all points within a circular region of radius R, is uniform in space and directed into the plane of the page as shown in the figure. If the magnetic field is decreasing with time t as $B = A\ exp(-C\ t)$, where C and A are constants, find the direction and the magnitude of the force on a stationary negative charge q located at position $(x = 3R, y=4R)$, defined from the center of the circular region.





Induced $\vec{E}$ is on the paper plane since $\vec{E} \perp \vec{B}$.

$\vec{F} = q\vec{E}$ q is negative so $\vec{F}$ is in the opposite direction of $\vec{E}$.

$$\oint_C \vec{E}\cdot d\vec{l} = -\frac{d\Phi_B}{dt} \Rightarrow |\vec{E}|\cdot 2\pi r = \pi R^2 . A\cdot C\cdot e^{-Ct} \qquad r = 5R$$

$$|\vec{E}| = \frac{R}{10}\cdot A\cdot C\cdot e^{-Ct}$$

To increase B, I is in clockwise direction and antiparallel to F at any point (parallel to $\vec{E}$)

$$\Rightarrow \vec{F} = |q|\cdot \frac{R}{10}\cdot A\cdot C\cdot e^{-Ct}\cdot \frac{1}{\sqrt{2}}(-\hat{i}+\hat{j})$$

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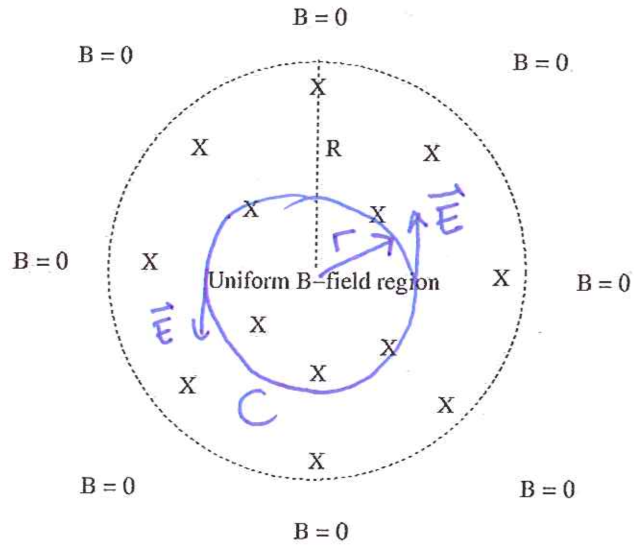
Section 5 **Quiz 9** **07 May 2015**

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

The magnetic field B, at all points within a circular region of radius R, is uniform in space and directed into the plane of the page as shown in the figure. If the magnetic field is increasing with time t as $B = A\,exp(C\,t)$, plot the magnitude of the induced electric field as a function of the radial distance r, defined from the center of the circular region.

$\vec{E} \perp \vec{B}$



For $r \leq R$:

$$\oint_C \vec{E}\cdot d\vec{\ell} = -\frac{d\Phi_B}{dt} = -\frac{d}{dt}\left(\pi r^2 \cdot A \cdot e^{Ct}\right)$$

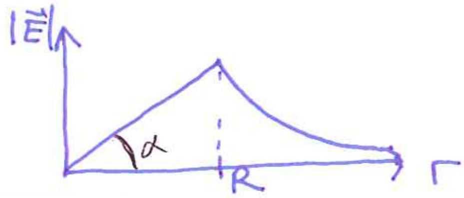
$$\Rightarrow |\vec{E}|\cdot 2\pi r = \pi r^2 \cdot A \cdot e^{Ct} \cdot C \quad \Rightarrow \quad |\vec{E}| = \frac{r}{2}\cdot A \cdot C \cdot e^{Ct}$$

For $r \geqslant R$

$$\oint_C \vec{E}\cdot d\vec{\ell} = -\frac{d\Phi_B}{dt} = -\frac{d}{dt}\left(\pi R^2 \cdot A \cdot e^{Ct}\right) \Rightarrow$$

$$|\vec{E}|\cdot 2\pi r = \pi R^2 \cdot A \cdot C \cdot e^{Ct} \Rightarrow |\vec{E}| = \frac{R^2}{2r}\cdot A \cdot C \cdot e^{Ct}$$

For a fixed t:



$$\tan\alpha(t) = \frac{1}{2} A \cdot C \cdot e^{Ct}$$