electromagnetic induction

changing $\vec{B}_{\text{ext}}$, or changing A, or changing θ $\vec{B}_{\text{ext}}$ ="external magnetic field" vector; unit=T	$\longrightarrow$ $\Phi_{\text{ext}B} = \int \vec{B}_{\text{ext}} \bullet d\vec{A}$ For a uniform ext$\vec{B}$: $\Phi_{\text{ext}B} = \text{ext}B_{\perp \text{ to surface}} \cdot A$ $= \text{ext}B_{\parallel \text{ to } \vec{A}} \cdot A$ $= \text{ext}\dot{B} \cdot \dot{A} \cdot \cos\theta$ $\vec{A}$ is a vector whose magnitude is the surface's area and whose direction is normal to the surface. θ is the angle between ext$\vec{B}$ and $\vec{A}$.	changing $\Phi_{\text{ext}B}$ "changing magnetic flux from the external magnetic field" scalar units= V · s	$\longrightarrow$ Faraday's law: $\mathcal{E}_{\text{induced}} = -\frac{d\Phi_{\text{ext}B}}{dt}$ $\lvert\mathcal{E}_{\text{induced}}\rvert = \frac{d\dot{\Phi}_{\text{ext}B}}{dt}$ If I_{ind} flows in positive direction, then $\mathcal{E}_{\text{ind}}>0$; if I_{ind} flows in negative direction, then $\mathcal{E}_{\text{ind}}<0$. $\longrightarrow$ Faraday's law: $\oint \vec{E}_{\text{ind}} \bullet d\vec{r} = -\frac{d\Phi_B}{dt}$ Dir $\vec{E}_{\text{ind}}$ is direction the current would flow if it existed.	$\mathcal{E}_{\text{induced}}$ "induced voltage" "induced emf" scalar unit = V = J/C $\vec{E}_{\text{ind}}$ "induced electric field" vector unit = N/C	$\longrightarrow$ *V=IR* Dir I_{ind} is determined from Lenz's law: 1. Is $\Phi_{\text{ext}B}$ increasing or decreasing? 2. Lenz's law says that dir $\vec{B}_{\text{ind}}$ *opposes the change* in $\Phi_{\text{ext}B}$. So, if $\Phi_{\text{ext}B}$ is increasing, then dir $\vec{B}_{\text{ind}}$ is opposite to dir ext$\vec{B}_{\perp\text{surface}}$; if $\Phi_{\text{ext}B}$ is decreasing, then dir $\vec{B}_{\text{ind}}$ is the same as dir ext$\vec{B}_{\perp\text{surface}}$. 3. Use the right-hand rule to find dir I_{ind} from dir $\vec{B}_{\text{ind}}$.	I_{induced} "induced current" scalar unit=A=C/s

First, get an *expression*, not a number, for $\Phi_{\text{ext}B}(t)$. *Then*, determine $\frac{d\dot{\Phi}_{\text{extB}}(t)}{dt}$. To find $\frac{d\dot{\Phi}_{\text{extB}}}{dt}$ you will need $\frac{dB_{\text{ext}}}{dt}$, $\frac{dA}{dt}$, or $\frac{d\cos(\theta)}{t}$.

Changing $\vec{B}_{\text{ext}}$: If given $\frac{dB_{\text{ext}}}{dt}$, use it. If given an expression for $B_{\text{ext}}(t)$, find $\frac{dB_{\text{ext}}(t)}{dt}$.

If given ΔB_{ext} and Δt with constant $\frac{dB_{\text{ext}}}{dt}$, find $\frac{dB_{\text{ext}}}{dt} = \frac{\Delta B_{\text{ext}}}{\Delta t}$.

Changing *A*: $A = lw$, so $\frac{dA}{dt} = l\frac{dw}{dt} = lv$.

Changing θ: $\theta = \omega t = 2\pi f t$, so $\frac{d\cos(\theta)}{t} = \frac{d\cos(2\pi f t)}{t} = -2\pi f \sin(2\pi f t)$.