A straight wire is carrying a constant current, I, in the direction as shown in the figure. A metal bar of length $L$ is moving with a constant velocity, $v$, parallel to the wire. The angle between the wire and the metal bar's axis is $\theta$. The distance between the wire and the closer end of the bar is $d$. Find the induced emf between the ends of the bar in terms of the given parameters.

$$
\varepsilon = \int \sin \theta \cdot v \cdot B(r) \, dr
$$

$$
\int_{d}^{d+L \sin \theta} \sin \theta \cdot v \cdot B(r) \, dr = \int_{d}^{d+L \sin \theta} \frac{I \omega}{2\pi r} \, dr
$$

$$
\varepsilon = \sin \theta \cdot v \cdot \frac{I \omega}{2\pi} \left( \ln \left( \frac{d+L \sin \theta}{d} \right) \right)
$$

$$
\varepsilon = \sin \theta \cdot v \cdot \frac{I \omega}{2\pi} \ln \left( \frac{d+L \sin \theta}{d} \right)
$$
A straight wire is carrying a current, $I$. A square metal loop is located at a distance from the wire, as shown in the figure. The current in the wire is changing as a function of time as shown in the graph below. Assume that the positive direction of the current in the wire is to the right and the positive direction of the current in the loop is clockwise. The induced current is shown between $t = 0$ and $t = 1$. Using this information and Lenz's Law, complete the plot of the induced current as accurately as possible. The magnitude of the induced current in different time intervals must be consistent.
A rectangular loop is located in the $y$-$z$ plane with one corner at the origin as shown in the figure. A magnetic field is present in space that is given by $\vec{B}(y,t) = B_0 y \sin(\omega t) \hat{z}$. If the resistance of the loop is equal to $R$, calculate the time-dependent induced current in the loop using Lenz's Law. Note: The magnetic field depends on $y$!

\[ E = -\frac{d\Phi}{dt} = -\frac{d}{dt} \int \vec{B} \cdot dA = -\frac{1}{2} \int_0^b \int_0^a B_0 y \sin(\omega t) dy dz \]

\[ = -\frac{1}{2} (a b^2 \sin(\omega t)) \frac{b^2}{2} = -\frac{a b^2}{2} B_0 \omega \cos(\omega t) \]

\[ I = \frac{E}{2R} = -\frac{a b^2}{2R} B_0 \omega \cos(\omega t) \]
A straight wire is carrying a constant current, $I$ to the right. A square metal bar is located at a distance from the wire, as shown in the figure. The bar is perpendicular to the wire axis. The induced voltage $V_{ab}$ between the ends of the wire is plotted as a function of time in the graph below. Using this information plot the velocity of the bar as a function of time as accurately as possible. The magnitude of the velocity at different time intervals must be consistent.
A metal bar can move without friction on two parallel metal railings horizontally. The bar has length $L$, mass $m$, and resistance $R$. The railings are connected through a switch to a capacitor with capacitance $C$. Initially, the switch is off, and the total charge of the capacitor is $Q$. The resistance of the railings are negligible. The bar and the railings are located within a uniform magnetic field, that is directed out of the page.

a) Suppose that when the switch is closed, the bar starts to move to the right. Which plate of the capacitor is at a higher potential, top or bottom?

b) Determine the acceleration of the bar just after the switch has been closed, in terms of the given parameters.