\( E = \left| \frac{d\Phi}{dt} \right| = -2b \frac{dx}{2\pi R} \frac{\mu_0 I}{R} \frac{b/2}{1} = \frac{\mu_0 I b^2 V}{2\pi \left(\frac{b}{2}\right)^2 + h^2} \)

The two \( dx \) strips contribute to the change in flux.
(7.26 Sliding bar)

At time $t=0$ the crossbar is moving to the right with speed $V_0$.

\[ \Phi = B b x \Rightarrow \frac{d\Phi}{dt} = v(t) b B = E(t) \quad \text{so} \quad I(t) = \frac{b B v(t)}{R} \]

Using the formula for the force on a current carry wire:
\[ F = I B b \] to the left.

\[ m \frac{d^2x}{dt^2} = -I(t) B b = -b^2 B^2 v(t) = m \frac{dv}{dt} \]

1st order diff eqn for $v(t)$:

\[ v(t) = V_0 \exp \left( -\frac{b^2 B^2 t}{m R} \right) \]

a) The rod never stops moving.

b) \[ d = \int_{t=0}^{\infty} \frac{dx}{dt} \, dt = \int_{t=0}^{\infty} \frac{V_0 \exp \left( -\frac{b^2 B^2 t}{m R} \right)}{m R} \, dt \]

\[ d = \frac{V_0 m R}{b^2 B^2} \]

c) The rod loses kinetic energy $\frac{1}{2} m V_0^2$.

The resistor dissipates $\int_0^{\infty} I^2(t) R \, dt$.
\[ R \cdot \frac{b^2 B^2}{R^2} \int_0^\infty (V(t))^2 \, dt = b^2 B^2 V_0^2 \int_0^\infty \exp\left(-\frac{2b^2 B^2}{m R} t\right) \, dt \]

\[ = \frac{b^2 B^2 V_0^2}{R} \frac{m R}{2b^2 B^2} = \frac{m V_0^2}{2} \]

\[ \checkmark \]
3. (7.27 Ring in a solenoid)

\[ \text{b, n, } I(+) = I_0 \cos \omega t \]

\[ \vec{B} = \mu_0 n I_0 \cos \omega t \hat{k} \text{ inside} \]

\[ \varepsilon = -\frac{d\Phi}{dt} = +\pi b^2 \omega \mu_0 n I_0 \sin \omega t \]

\( n \text{ Ind when } \vec{B} \text{ is increasing (clockwise = negative)} \)

(a) Induced current \[ \frac{\varepsilon}{R} = +\pi b^2 \omega \mu_0 n I_0 \sin \omega t \]

(positive sign means counterclockwise)

(b) \[ dF = \text{Ind} \vec{B} \, dl = \pi b^2 \omega (\mu_0 n I_0)^2 \sin \omega t + \cos \omega t \]

\[ \text{max at } t = \frac{(\pi/2) + m(2\pi)}{2\omega} \]

where \( m \) is an integer

(c) The ring will alternate between shrinking and expanding

- If \( B \) is pos and increasing, shrink
- If \( B \) is pos and decreasing, expand
- If \( B \) is neg and increasing, expand
- If \( B \) is neg and decreasing, shrink
5. (7.33 Getting a ring to spin)

\[ \lambda = \frac{q}{2\pi a} \]

Switch the field off: \( \frac{dB(t)}{dt} \to 0 \) from \( t = 0 \) to \( t = t_f \)

\[ \int_{0}^{t_f} \frac{dB(t)}{dt} dt = -B_0 \]

(this is a quick way of turning off the field)

\[ \vec{B}(t) \text{ out of the page} \]

\[ \frac{dB(t)}{dt} < 0 \Rightarrow \Phi(+) \text{ is decreasing} \]

\[ \Rightarrow \text{induced } \vec{E} \text{ field is counterclockwise} \]

\[ \int \vec{E} \cdot d\vec{l} = 2\pi a E(t) = -\frac{dB(t)}{dt} \pi a^2 \Rightarrow E(+) = \frac{dB(+)a}{dt} 2 \]

Remember angular motion from last fall

\[ ma^2 \frac{d\omega}{dt} = (qE) a \Rightarrow \frac{d\omega}{dt} = \frac{q}{ma} \frac{a}{2} \frac{dB}{dt} \]

integrate both sides \( \omega(t) = \frac{q}{2m} (+B_0) \) √