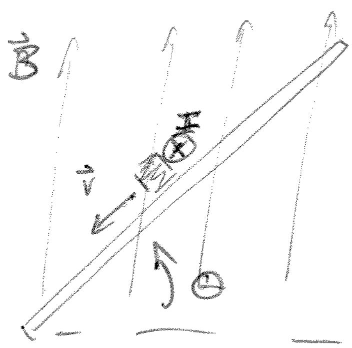
General Problem Solving Guide

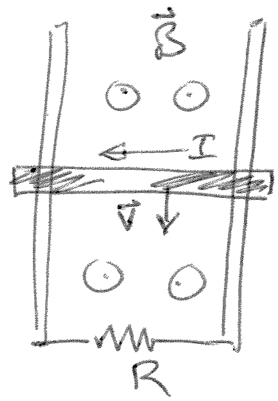
Date:	
Recorder:	KEY
Skeptic:	
Timekeeper:	
Psychic:	

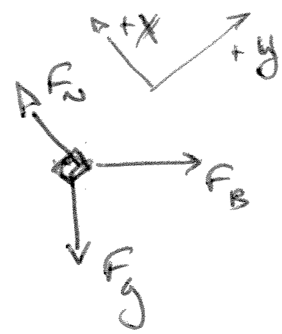
[5] List given information, define variables, sketch picture:

SIDE



TOP





* Assume no friction

[1] Simplify question, list target quantity:

Find velocity of bar sliding down incline

[3] List all related quantitative relationships:

$\sum \vec{F} = \frac{d\vec{p}}{dt} = 0$ (constant velocity)

$\vec{F} = q\vec{v} \times \vec{B}$ or w/ current $\vec{F} = l\vec{I} \times \vec{B}$

$V = IR$ $\quad \vec{F} = q\vec{E}$ and $-\int \vec{E} \cdot d\vec{x} = \Delta V$ or $\vec{E} = \frac{\Delta V}{\Delta x}$

[2] Outline approach, sketch diagrams if needed (or sketch next to pictures above):

- Find Force on charges (in metal rod) falling through magnetic field
- Find Voltage from force (via Hall Effect approach)
- Find current using Ohm's Law
- Find F_B from current flowing in metal rod
- Balance forces and solve for velocity

Obtain a general solution: [2]

Force on charges (magnitude)

$F = qvB\sin(\theta + \frac{\pi}{2}) = qvB\cos\theta$

$F = qE \quad \therefore \quad E = vB\cos\theta$

Find voltage drop (charges/current move to the left in TOP view)

$\frac{\Delta V}{\ell} = vB\cos\theta$

$\Delta V = vB\ell\cos\theta$

Find current

$I = \frac{\Delta V}{R} = \frac{vB\ell\cos\theta}{R}$

Find F_B (magnitude)

$F_B = I\ell B$ since angle is 90° between current and $\vec{B}$

$= \frac{v(B\ell)^2\cos\theta}{R}$

F_B direction is horizontal

X: $\Sigma F = 0 = F_N - F_B\sin\theta - mg\cos\theta$

Y: $\Sigma F = 0 = F_B\cos\theta - mg\sin\theta$

$\therefore \frac{v(B\ell)^2\cos\theta}{R} = F_B = \frac{mg\sin\theta}{\cos\theta}$

solve for v

$v = \frac{mgR\sin\theta}{(B\ell\cos\theta)^2}$

Check Units: [2]

$\frac{m}{s} = \frac{(kg\,m/s^2)\cdot\Omega}{T^2 m^2} = N\cdot\frac{N\,ms}{C^2 m^2}\cdot\frac{(Cm)^2}{(Ns)^2} = \frac{m}{s}$ ✓

$N = C\frac{m}{s}T$ and $\Omega = \frac{N\,ms}{C^2}$

($F = qvB$) ($V = IR$, $F = qE$, $E = \frac{\Delta V}{\Delta x}$)

Check Limiting Cases: [2]

B↑ v↓ ✓

ℓ↑ v↓ ✓ more length

R↑ v↑ ✓ (less current)

m↑ v↑ ✓

g↑ v↑ ✓

θ=0 v=0 ✓

θ↑ v↑ (θ=90° v→∞ a≠0!)

Obtain a numeric solution:
(i.e. plug in the numbers) [1]

$|V| = \frac{mgR\sin\theta}{(B\ell\cos\theta)^2}$

Why is solution reasonable? Explain. [2]

units work

limiting cases work

θ = 0° and θ = 90° make sense