

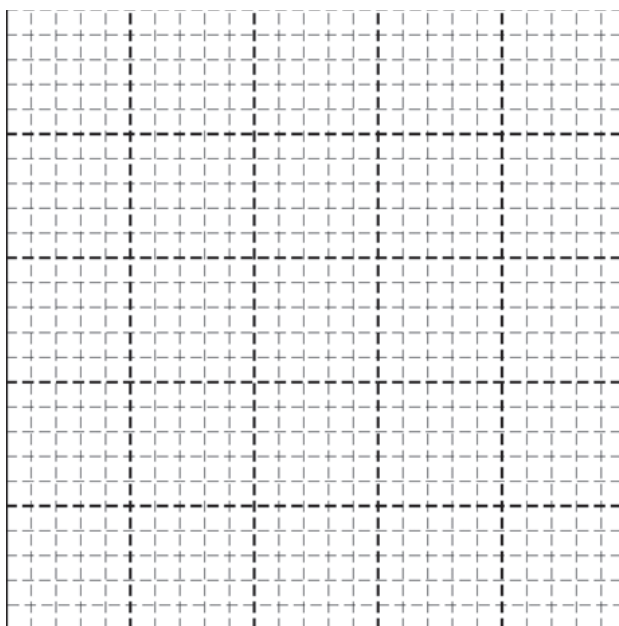
E&M.2.

A student performs an experiment to determine the emf $\mathcal{E}$ and internal resistance r of a given battery. The student connects the battery in series to a variable resistance R , with a voltmeter across the variable resistor, as shown in the figure above, and measures the voltmeter reading V as a function of the resistance R . The data are shown in the table below.

Trial #	Resistance (Ω)	Voltage (V)	$1/R$ ($1/\Omega$)	$1/V$ ($1/V$)
1	0.50	5.6	2.00	0.179
2	1.0	7.4	1.00	0.135
3	2.0	9.4	0.50	0.106
4	3.0	10.6	0.33	0.094
5	5.0	10.9	0.20	0.092
6	10	11.4	0.10	0.088

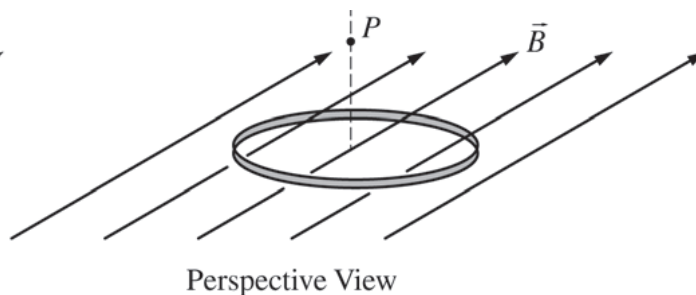
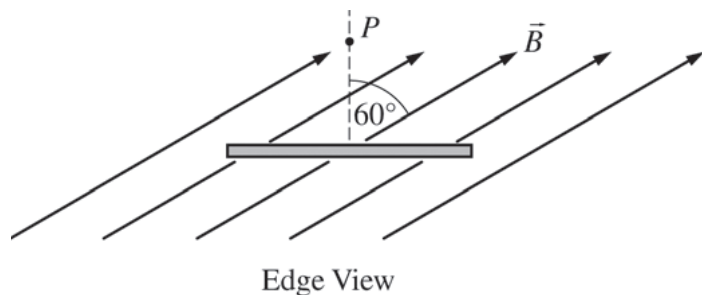
- (a)
- Derive an expression for the measured voltage V . Express your answer in terms of R , $\mathcal{E}$, r , and physical constants, as appropriate.
 - Rewrite your expression from part (a)-i to express $1/V$ as a function of $1/R$.

- (b) On the grid below, plot data points for the graph of $1/V$ as a function of $1/R$. Clearly scale and label all axes, including units as appropriate. Draw a straight line that best represents the data.



- (c) Use the straight line from part (b) to obtain values for the following.
- $\mathcal{E}$
 - r
- (d) Using the results of the experiment, calculate the maximum current that the battery can provide.
- (e) A voltmeter is to be used to determine the emf of the battery after removing the battery from the circuit. Two voltmeters are available to take this measurement—one with low internal resistance and one with high internal resistance. Indicate which voltmeter will provide the most accurate measurement.
- ___ The voltmeter with low resistance will provide the most accurate measurement.
- ___ The voltmeter with high resistance will provide the most accurate measurement.
- ___ The two voltmeters will provide equal accuracy.

Justify your answer.



E&M. 3.

A circular wire loop with radius 0.10 m and resistance $50\ \Omega$ is held in place horizontally in a magnetic field $\vec{B}$ directed upward at an angle of 60° with the vertical, as shown in the figure above. The magnetic field in the direction shown is given as a function of time t by $B(t) = a(1 - bt)$, where $a = 4.0\text{ T}$ and $b = 0.20\text{ s}^{-1}$.

- (a) Derive an expression for the magnetic flux through the loop as a function of time t .
- (b) Calculate the numerical value of the induced emf in the loop.
- (c)
- Calculate the numerical value of the induced current in the loop.
 - What is the direction of the induced current in the loop as viewed from point P ?
☐ Clockwise ☐ Counterclockwise
Justify your answer.
- (d) Assuming the loop stays in its current position, calculate the energy dissipated in the loop in 4.0 seconds.
- (e) Indicate whether the net magnetic force and net magnetic torque on the loop are zero or nonzero while the loop is in the magnetic field.
- Net magnetic force: ☐ Zero ☐ Nonzero
- Net magnetic torque: ☐ Zero ☐ Nonzero
- Justify both of your answers.

STOP
END OF EXAM