Exam 2 covers

HWs 5-9

General topics:

UNITS!!

Distinguish between scalars and vectors.

When is a line integral zero?
Hw5: Capacitance matrix, energy stored in capacitor, energy density of electric field

Capacitance matrix: two or more conductors
HW6: current and current density

Equation of continuity

Steady current condition

Definition of resistance, Ohm’s law $V=IR$ and $j=\sigma E$

Finding the resistance of an object by putting it into a black box with 2 leads
(resistance of object depends where the leads are attached)

Finding the resistance of an object from $E$ field and $\sigma$
HW7: Analyzing circuits: currents, voltage differences, power

Labeling the diagram: current in each branch, loop currents
Kirchoff: loop rule, junction rule

Circuit elements: ideal battery, resistor
real batteries, light bulbs

Equivalent circuit elements – concept
Pure resistive networks – series, parallel

THENEVIN EQUVALENTS

Using symmetry in the circuit, other global reasoning.

(RC CIRCUITS?)
2. (10 pts) Consider the resistor network shown in the figure. Note all the resistors have the same resistance $R$ except for one, which has resistance $2R$. Given the indicated currents observed when the network is inserted into a particular circuit, find the effective resistance between points A and B.
6. (20 pts) Find the Thenevin equivalent resistance and emf for the circuit shown in the figure. If a 15 \( \Omega \) resistor is connected across the terminals, how much power does it dissipate?

\[
\begin{align*}
\text{80 V} & \\
\text{6 \( \Omega \)} & \quad \text{20 V} \\
\text{6 \( \Omega \)} & \quad \text{6 \( \Omega \)} \\
\text{7 \( \Omega \)} & \\
\end{align*}
\]
HW7: Analyzing circuits: currents, voltage differences, power

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THENEVIN EQUIVALENTS

Using symmetry in the circuit, other global reasoning.

(RC CIRCUITS?)
Magnetic force on a moving charge: circular motion, crossed fields, no work done

Force on current carrying wire, loop
– add up segments – need field to be uniform on each segment

What do you do if the field is not uniform?
Cancellation strategy in homework problem, integral

Torque on loop?

1. (5 pts) A positively charged particle is moving with velocity \( \vec{v} \) in the \( z \) direction. If the uniform magnetic field \( \vec{B} \) points in the \( -x \) direction, what is the direction of the magnetic force \( \vec{F} \)? Draw a sketch showing the three vectors.
Magnetic fields produced by steady current distribution 
Div B = 0 – field lines don’t begin or end 
Symmetry and superposition 
Ampere vs Biot Savart 

Symmetric current distributions we can analyze with Ampere 
Straight wire, cylinders j(r) 
How to shift the origin! Rhat and theta hat. Important for correct writing of sum of field of two or more objects 

Get j from B via differential form of Ampere’s law 

Biot-Savart 
Usually integrate over the segment – sometimes the integral becomes trivial 
Circular arc – field at center 
Field of semi-infinite wire segment 

KNOW THE FIELD OF A RING ON THE AXIS – superposition gives you field of rotating charge distributions 
SOLENOID 
SHEET
4. (10 pts) If \( \vec{B}(\vec{r}) = B_0 \frac{\sigma}{\alpha} \hat{j} \), what is the current enclosed by the closed loop shown?  
   OPTIONAL: What is the current density \( \vec{J}(\vec{r}) \)?

\[
\begin{array}{c}
\text{y} \\
(0,a) \quad \text{(a,a)} \\
(0,0) \quad \text{(a,0)} \\
\end{array}
\]

\[
\begin{array}{c}
x \\
\end{array}
\]
3. (10 pts) A ring of wire with radius \( a \) and positive uniform linear charge \( \lambda \) spins around its center with angular frequency \( \omega \), as shown in the figure. What is the direction and magnitude of the resulting magnetic field at the center of the ring?
7. (20 pts) Consider the arrangement of two infinite straight wires running in the \(-y\) direction (straight out of the page in the figure on the left) with equal currents \(I\).

(a) What is the magnitude and direction of the magnetic field at the point \(P=(x,0,0)\)? Show your reasoning.

(b) A square loop with current \(I_1\) running in the direction of the arrows is placed in the \(xy\) plane as shown in the figure in the center. A top view is shown in the figure on the right. What is the direction of the magnetic force on the loop? Show your reasoning.

OPTIONAL: Explain how to find the direction of \(B\) (up to a sign) at the point \(P\) using only symmetry arguments.