Week 2
To find the magnetic field $B$ due to a current-carrying wire, below, we use the Biot-Savart law,

$$\vec{B}(\vec{r}) = \frac{\mu_0}{4\pi} I \int \frac{\vec{dl} \times \hat{R}}{R^2}$$

What is the magnitude of $\frac{\vec{dl} \times \hat{R}}{R^2}$?

a) $\frac{dl \sin \theta}{R^2}$

b) $\frac{dl \sin \theta}{R^3}$

c) $\frac{dl \cos \theta}{R^2}$

d) $\frac{dl \cos \theta}{R^3}$

e) $\frac{dl}{R^2}$

1.1
To find the magnetic field \( B \) due to a current-carrying loop, we use the Biot-Savart law,

\[
\vec{B}(\vec{r}) = \frac{\mu_0}{4\pi} \int \frac{d\vec{l} \times \hat{R}}{R^2}
\]

What is the magnitude of \( \frac{d\vec{l} \times \hat{R}}{R^2} \)?

A) \( \frac{dl \sin \phi}{z^2} \)  
B) \( \frac{dl}{z^2} \)  
C) \( \frac{dl \sin \phi}{(z^2 + a^2)} \)  
D) \( \frac{dl}{(z^2 + a^2)} \)  
E) Something quite different!
To find the magnetic field $B$ due to a current-carrying loop, we use the Biot-Savart law,

$$\vec{B}(\vec{r}) = \frac{\mu_0}{4\pi} I \int \frac{d\vec{l} \times \hat{R}}{R^2}$$

What is the $dB_z$ (the contribution to the vertical component of $B$ from this $dl$ segment?)

A) $\frac{dl}{z^2 + a^2} \frac{a}{\sqrt{z^2 + a^2}}$  
B) $\frac{dl}{z^2 + a^2}$

C) $\frac{dl}{z^2 + a^2} \frac{z}{\sqrt{z^2 + a^2}}$  
D) $\frac{dl \cos \phi}{z^2 + a^2}$

E) Something quite different!

Diagram:
- Point P at $(0,0,z)$
- Loop with radius $a$
- Current $I$
- $dl$ segment
- Angle $\phi$
What is $\oint \mathbf{B} \cdot d\mathbf{l}$ around this purple (dashed) Amperian loop?

A) $\mu_0 (|I_2| + |I_1|)$
B) $\mu_0 (|I_2| - |I_1|)$
C) $\mu_0 (|I_2| + |I_1| \sin \theta)$
D) $\mu_0 (|I_2| - |I_1| \sin \theta)$
E) Something else!
Two long coaxial solenoids each carry current $I$ but in opposite directions.

The inner solenoid (radius $a$) has $n_1$ turns per unit length, and the outer one (radius $b$) has $n_2$.

Find $B$ (i) inside the solenoid, (ii) between them, and (iii) outside both.

Figure 5.42
What is \( \int \mathbf{A}(\mathbf{r}) \cdot d\mathbf{l} \)?

A) The current density \( J \)
B) The magnetic field \( B \)
C) The magnetic flux \( \Phi_B \)
D) It's none of the above, but is something simple and concrete
E) It has no particular physical interpretation at all

1.6
Can you calculate that integral using spherical coordinates?

A) Yes, no problem
B) Yes, r' can be in spherical, but J still needs to be in Cartesian components
C) No.
An electric current \( I \) flows along a copper wire (low resistivity) into a resistor made of carbon (high resistivity) then back into another copper wire. 

*In which material is the electric field largest?*

A. In the copper wire  
B. In the carbon resistor  
C. It’s the same in both copper and carbon  
D. It depends on the sizes of the copper and carbon