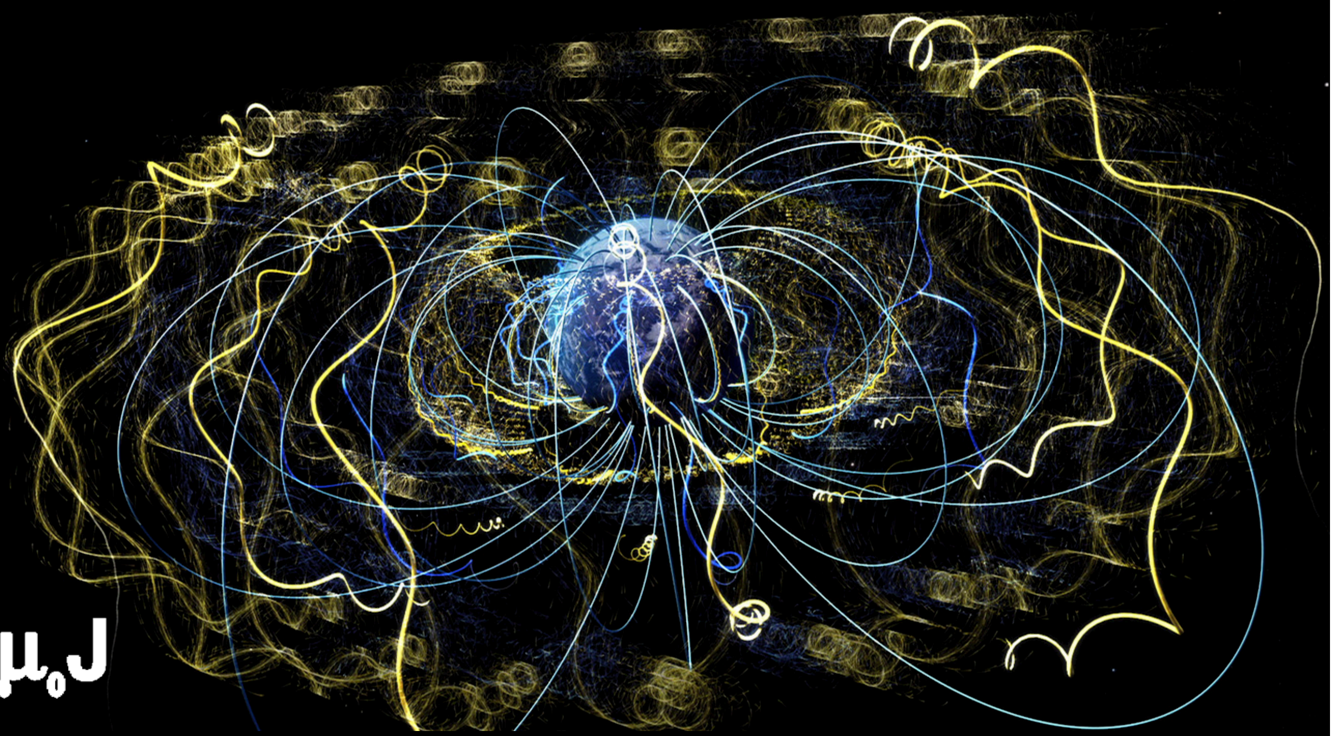
$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

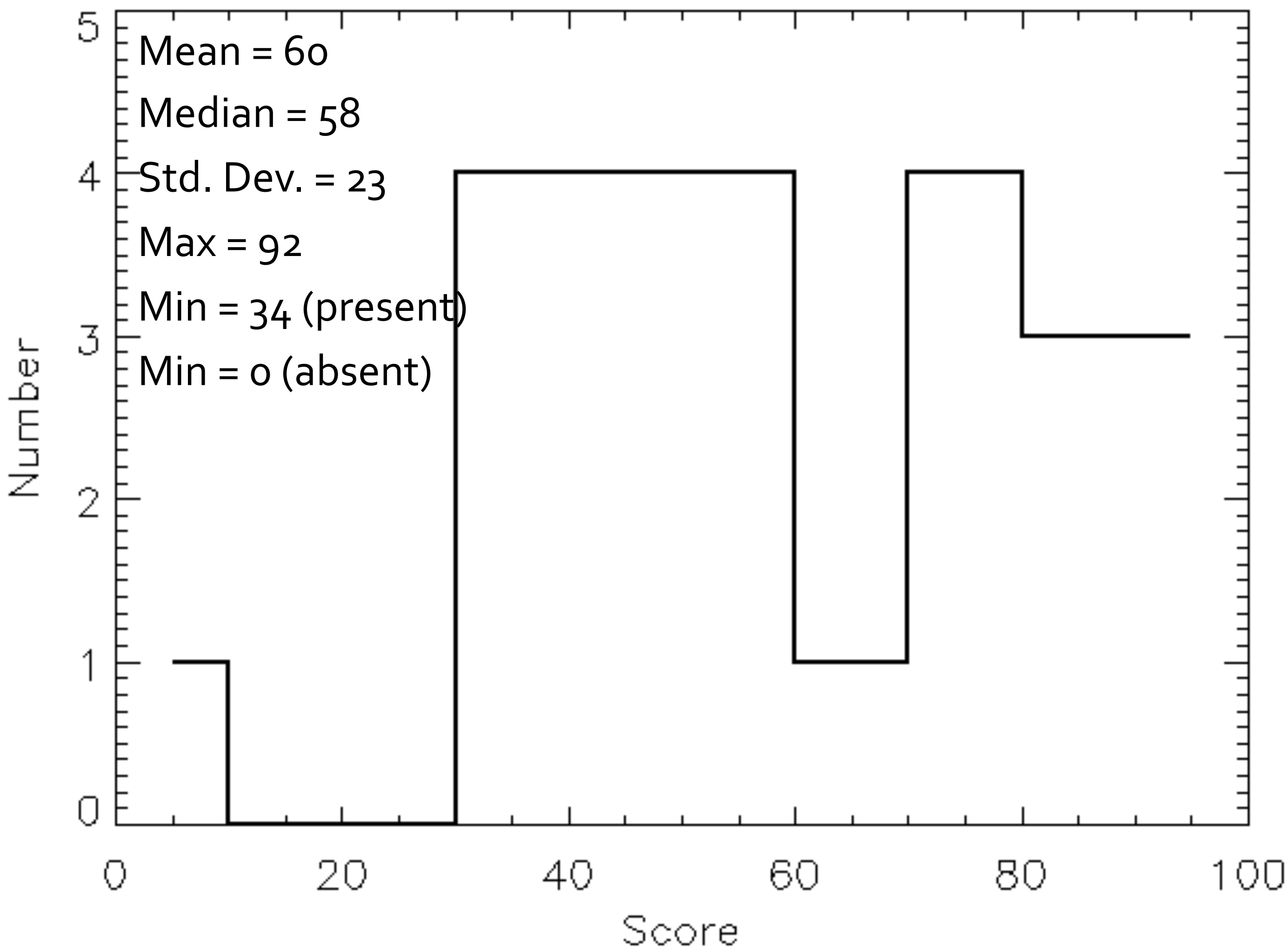
$$\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} + \mu_0 \mathbf{J}$$



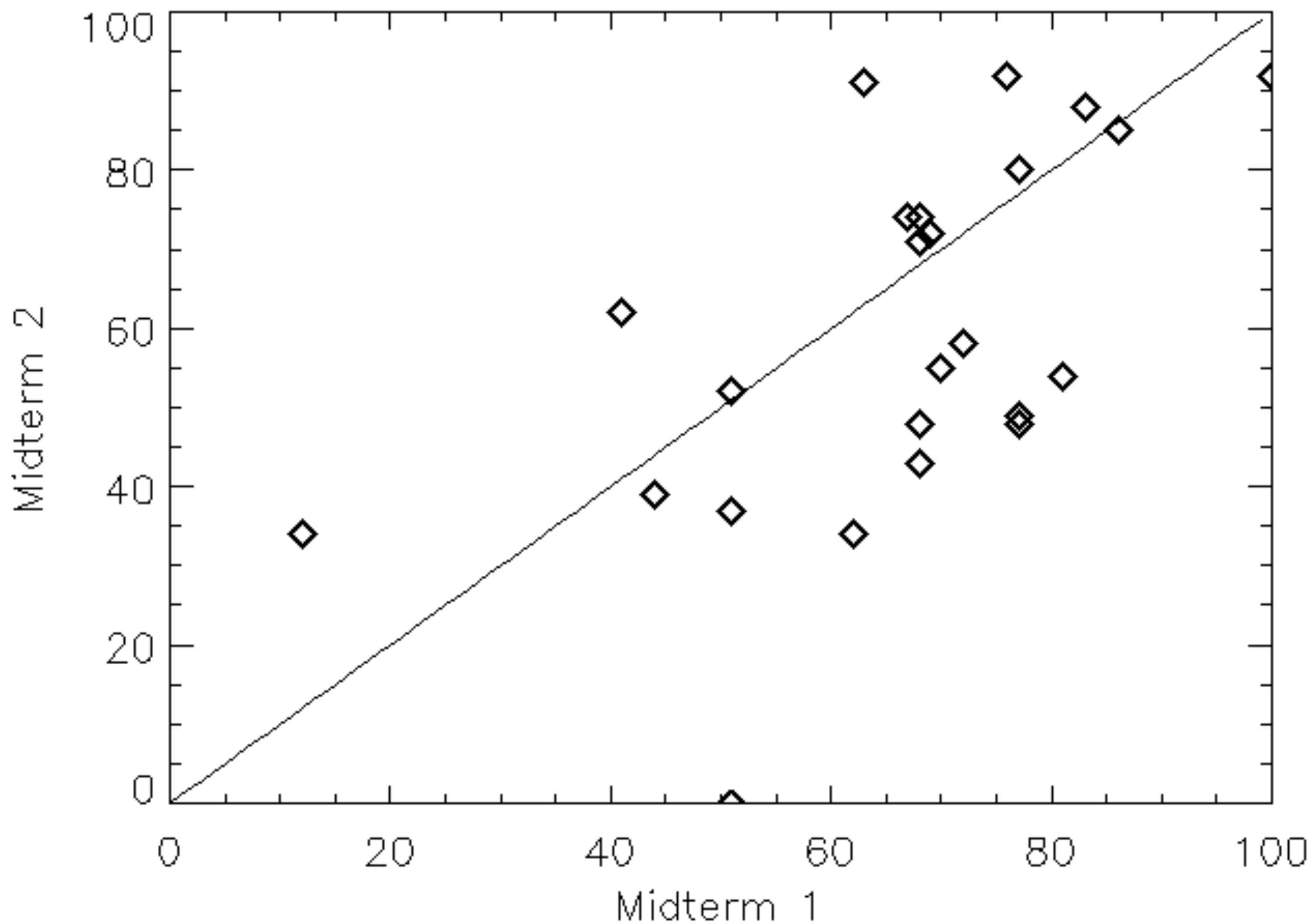
Electricity and Magnetism I: 3811

Professor Jasper Halekas
Van Allen 301
MWF 9:30-10:20 Lecture

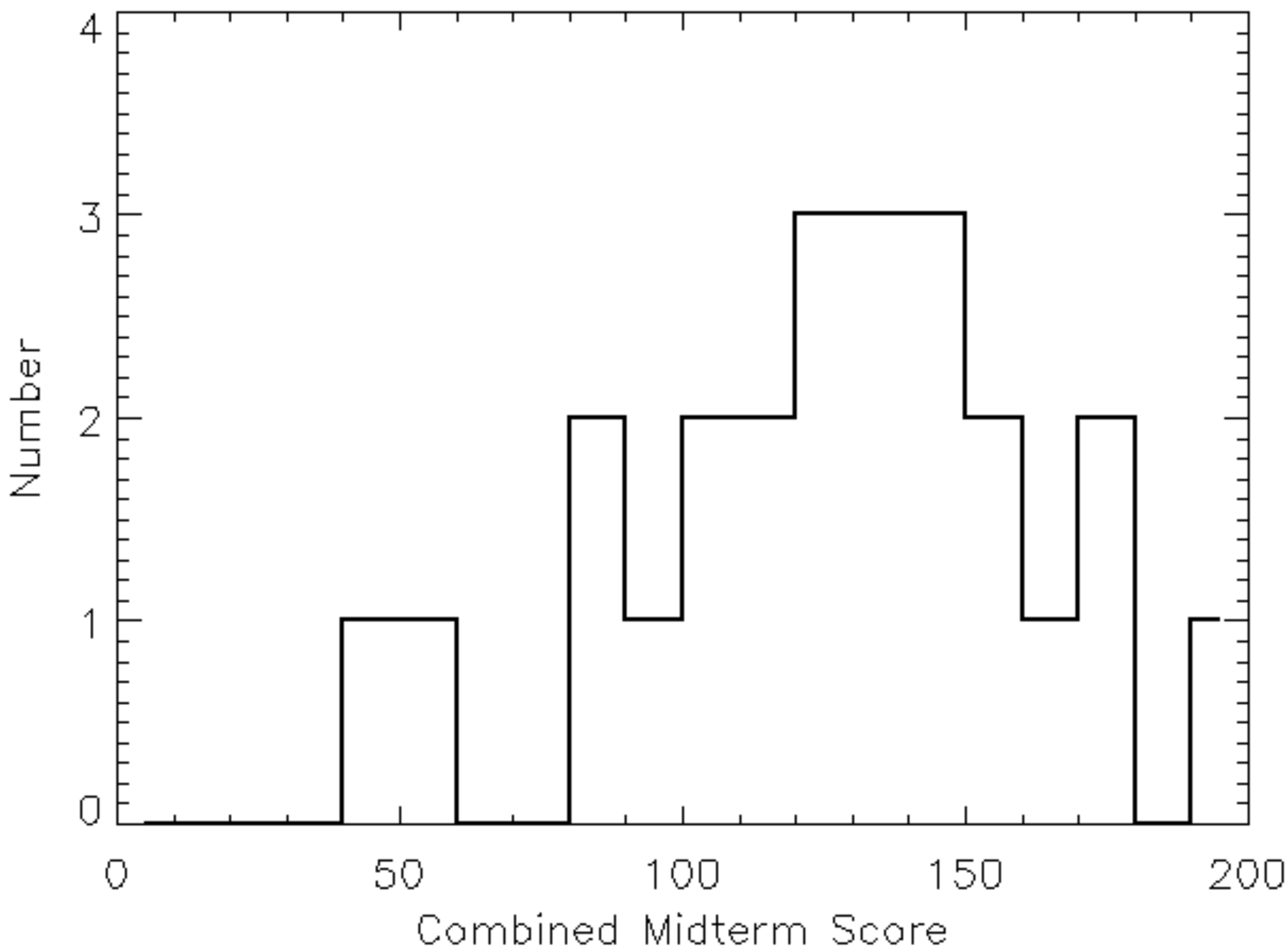
Exam 2 Results



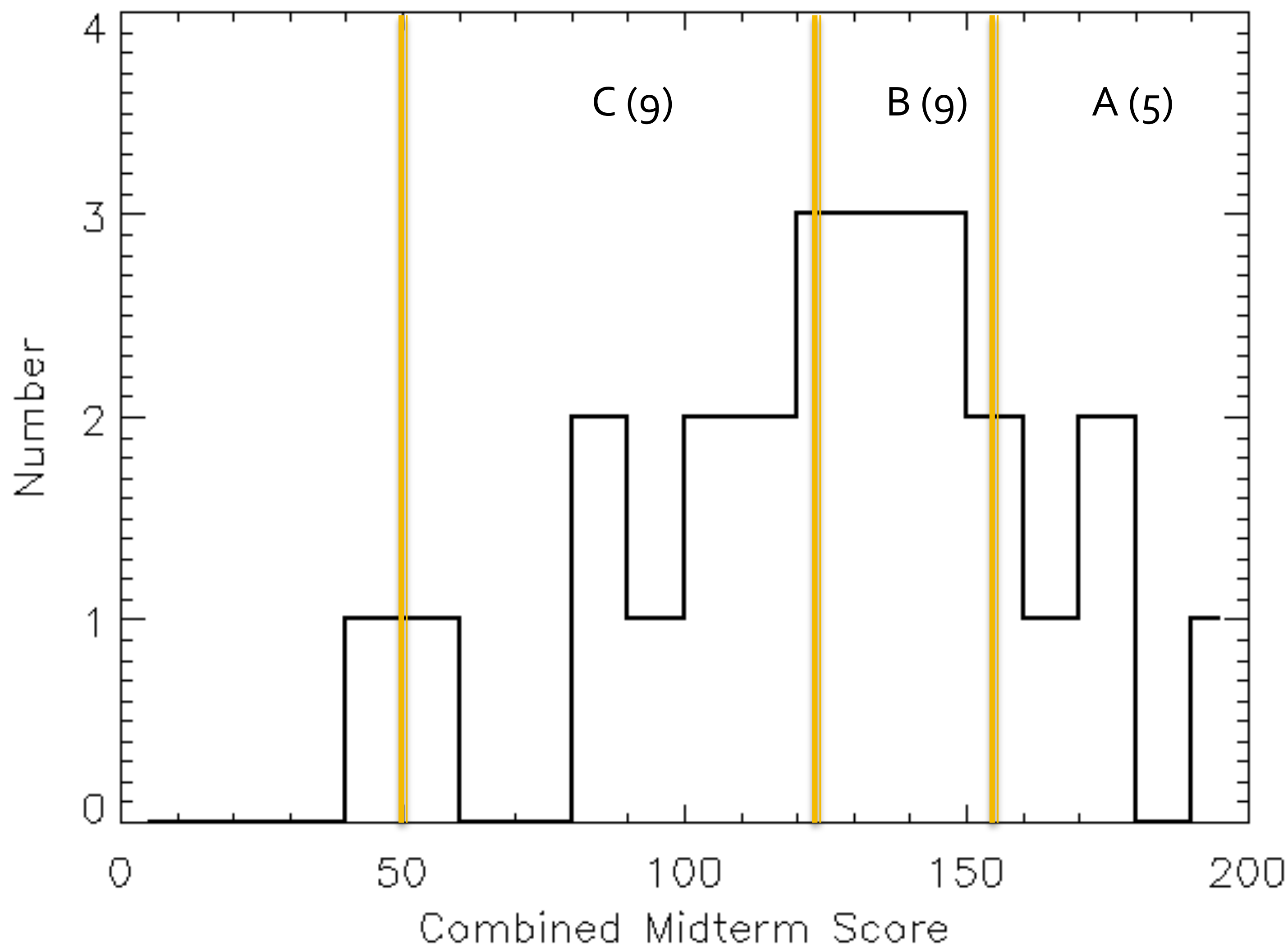
Score Correlation



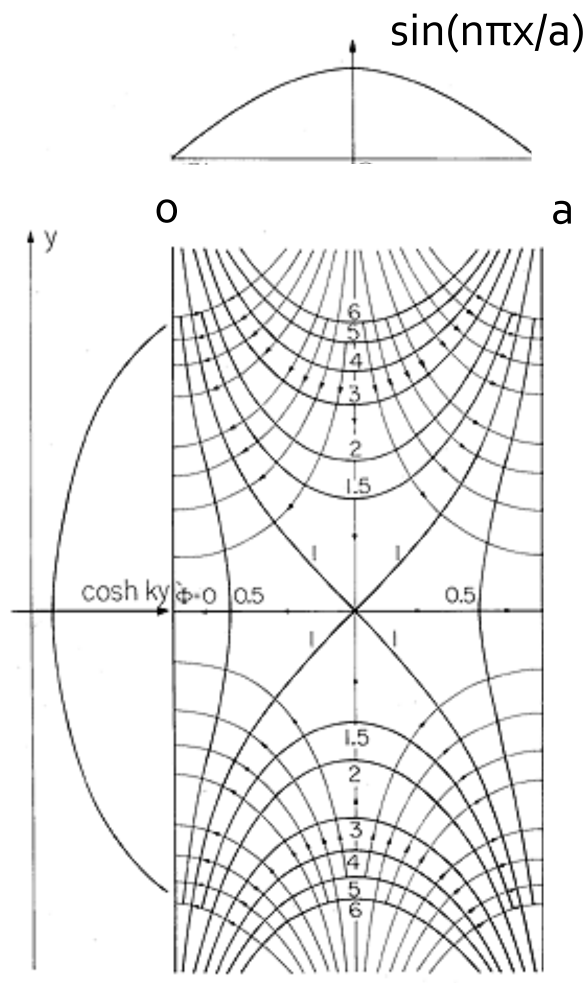
Combined Midterm Results



Very Rough Grade Distribution for Standard CLAS Advanced Curve



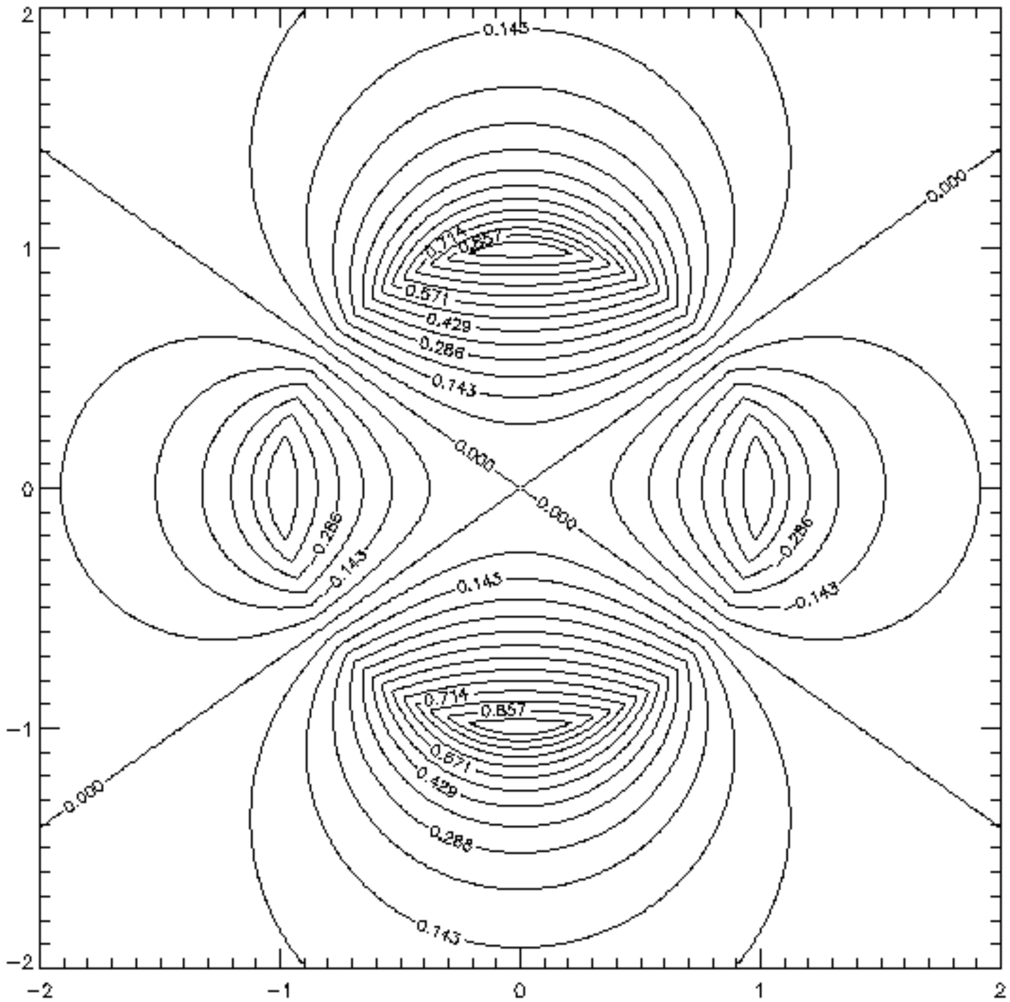
Exam 2: Question 1



Separation of Variables
Cartesian Coordinates

Boundary Conditions

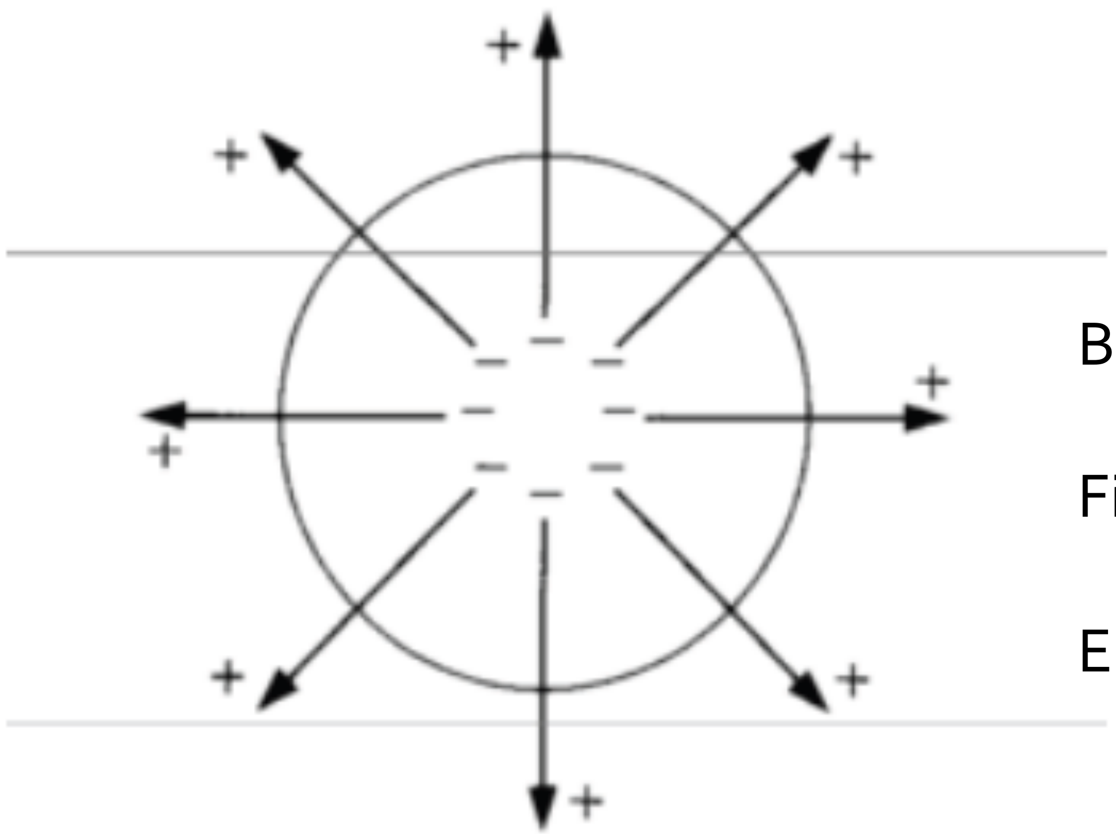
Exam 2: Question 2



Separation of Variables
Spherical Coordinates

Boundary Conditions

Exam 2: Question 3

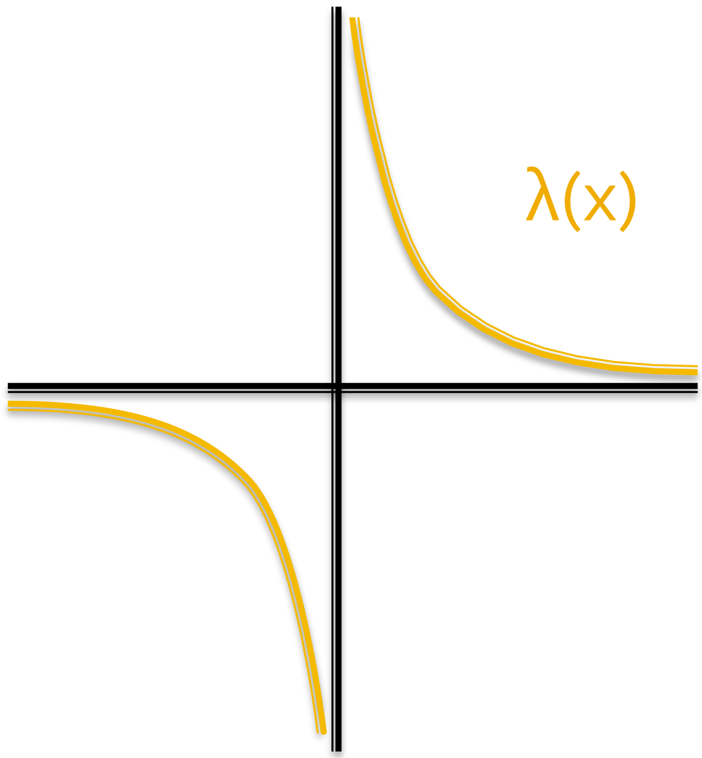


Bound Charge

Fields of Polarized Material

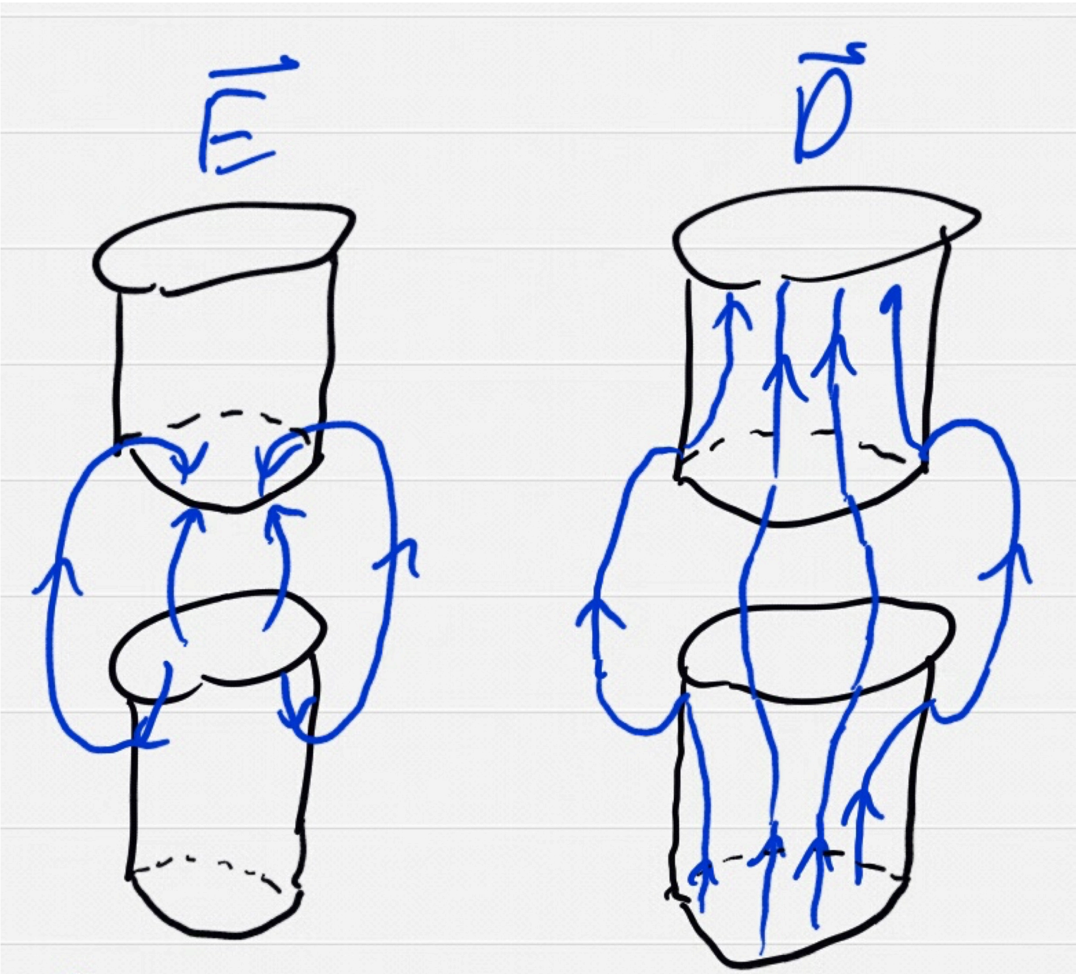
Electric Displacement

Exam 2: Question 4



Dipole Moment

Exam 2: Question 5



Bound Charge

Fields of Polarized Material

Electric Displacement

Bad Art

Electrostatics

- No moving charges
  $\Rightarrow$ no magnetic fields

Magnetostatics

- steadily moving charges (steady currents)
- No changing currents

$\Rightarrow$ steady magnetic fields

No electromagnetic radiation

Lorentz Force Law

$$\vec{F} = Q(\vec{E} + \vec{v} \times \vec{B})$$

$\vec{F}_e = Q\vec{E}$ on all charges, parallel to $\vec{E}$

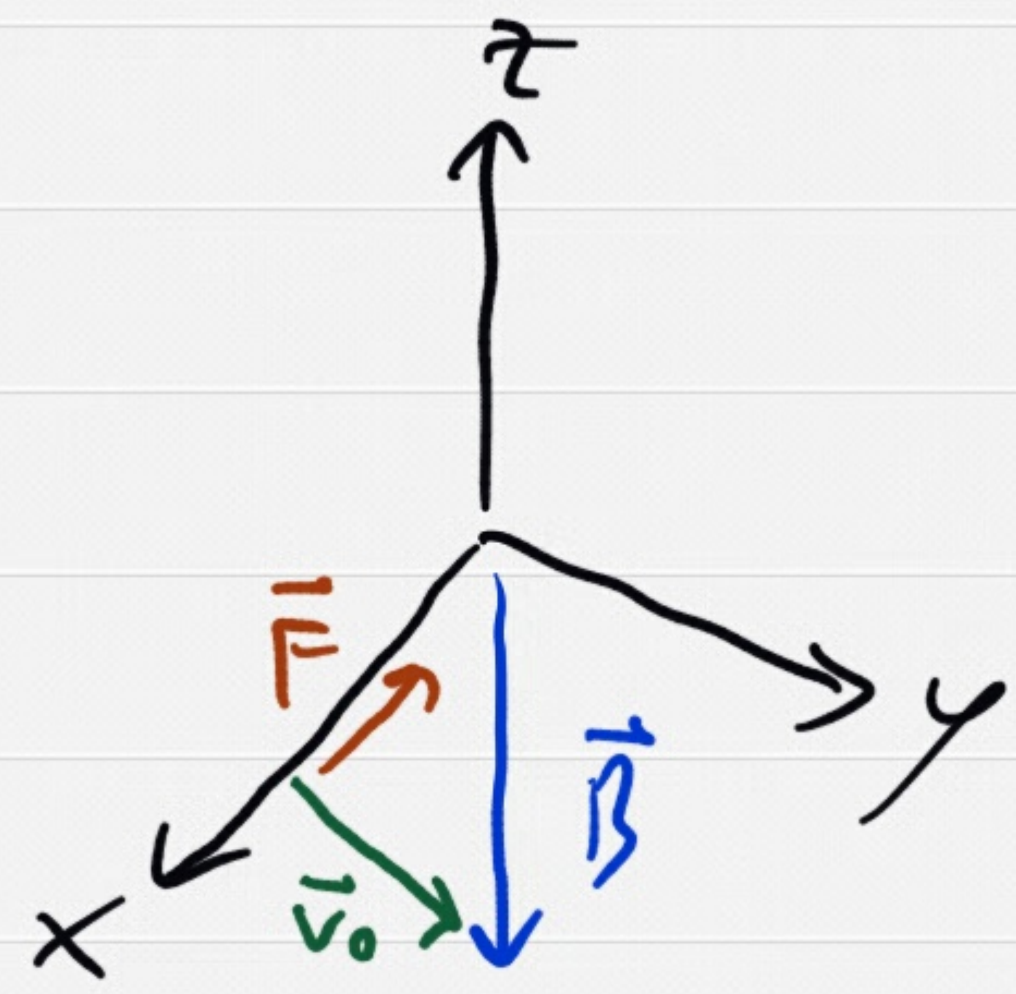
$\vec{F}_b = Q(\vec{v} \times \vec{B})$ only on moving charges, perpendicular to $\vec{B}$

Example: Cyclotron Motion

$\vec{B} = -B\hat{z}$

$\vec{r}_0 = x\hat{x}$

$\vec{v}_0 = v\hat{y}$



$$\vec{F}_0 = Q\vec{v}_0 \times \vec{B} = QvB \cdot -\hat{x}$$

$\vec{F} \perp \vec{v} \Rightarrow |\vec{v}| = \text{const.} = v$

$\Rightarrow$ circular motion

$$QvB = \frac{mv^2}{R} \Rightarrow R = \frac{mv}{QB}$$

$$\omega = v/R = \frac{QB}{m} = \text{cyclotron frequency}$$

If $\vec{v}_0$ has a component along $\vec{B}$, separate into

$v_\parallel$, $v_\perp$

$v_\parallel = \text{const.}$, $|v_\perp| = \text{const.}$

$$Q v_\perp B = \frac{m v_\perp^2}{R} \Rightarrow R = \frac{m v_\perp}{qB}$$

helical path

— Note: cyclotron motion is not technically magnetostatics since charges are accelerated

Gyro-Motion

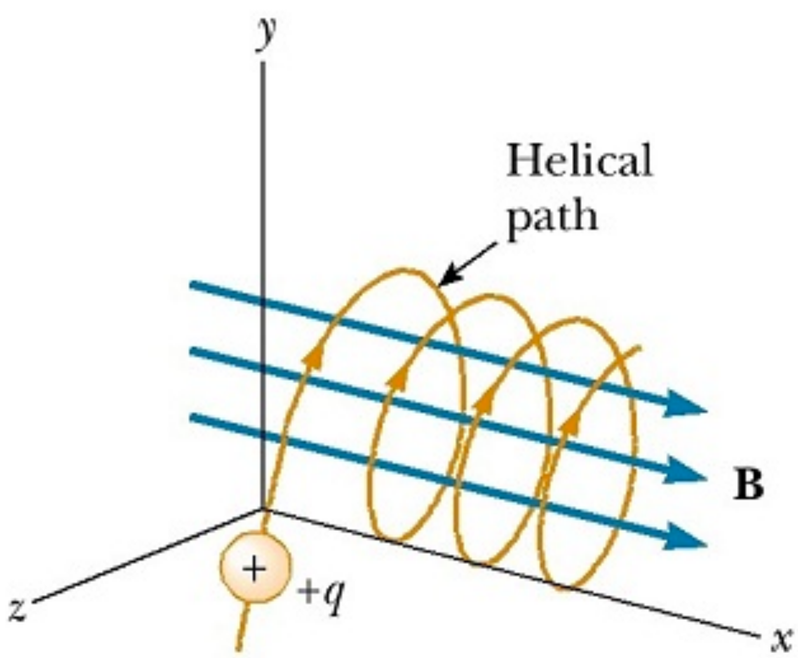


Figure 29.18 A charged particle having a velocity vector that has a component parallel to a uniform magnetic field moves in a helical path.

Ions = Left-Handed Gyration
Electrons = Right-Handed Gyration

Magnetic Forces & Work

$$\vec{F}_b = Q\vec{v} \times \vec{B}$$

$$W = \int \vec{F}_b \cdot d\vec{l}$$

$$= \int \vec{F}_b \cdot \frac{d\vec{l}}{dt}\, dt$$

$$= \int \vec{F}_b \cdot \vec{v}\, dt$$

$$= 0$$

- Magnetic Forces do No Work!
- Sometimes hard to tell what does work, but it's never static magnetic fields