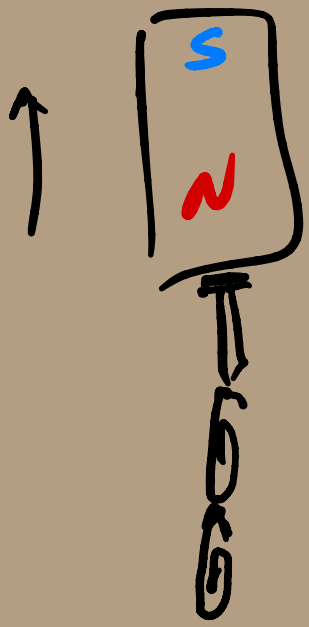
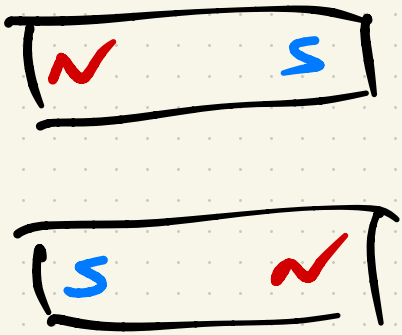
Lecture 17 questions

(magnets)



Question 1

(A) Suppose we have two bar magnets "side by side":

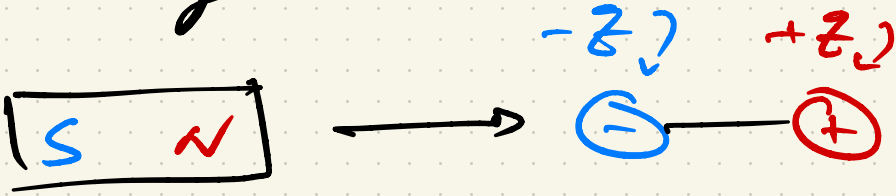


- Will they experience:
  - Attraction?
  - Repulsion?
  - Neither?
- Answer using two different methods:

Q1a cont.

METHOD 1:

- SUBSTITUTE THE NORTH & SOUTH MAGNETIC POLES FOR POSITIVE & NEGATIVE ELECTRIC CHARGES, RESPECTIVELY:

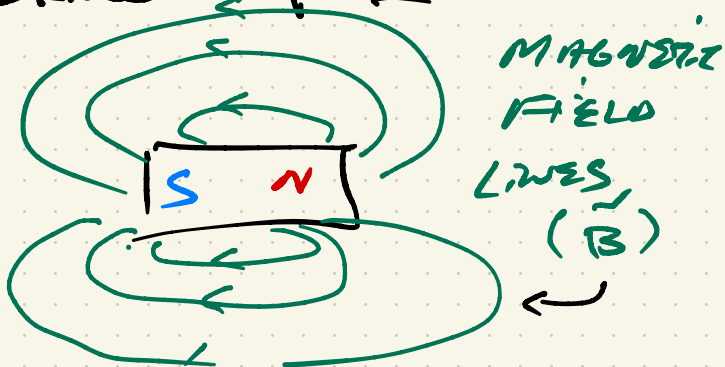


- THEN, USE THE COULOMB FORCE LAW AND THE SUPERPOSITION PRINCIPLE TO DETERMINE THE DIRECTION OF THE FORCE ON EITHER MAGNET.
- NO CALCULATIONS! DRAW A PICTURE!
- CHECK THAT THE FORCE ON THE OTHER MAGNET IS EQUAL + OPPOSITE.

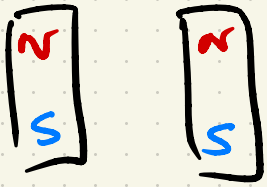
Q1a cont.

METHOD 2:

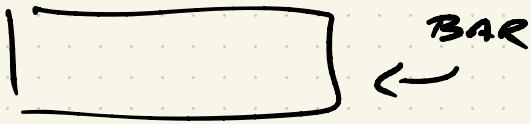
- Keeping the N → ⊕, S → ⊖ substitution, superimpose the (Dipole) electric field lines generated by one of the Dipoles.
- Determine the force on the other Dipole by using the eqn $\vec{F} = q\vec{E}$, along of the superposition principle.
- Again, no calculations!
  - Draw a picture!
  - Hint:



(B) SAME QUESTION AS (A) BUT NOW:



(C) NOW WE HAVE ONE BAR MAGNET & BEING A BAR OF INITIALLY UNMAGNETIZED IRON CLOSE TO THE MAGNET:



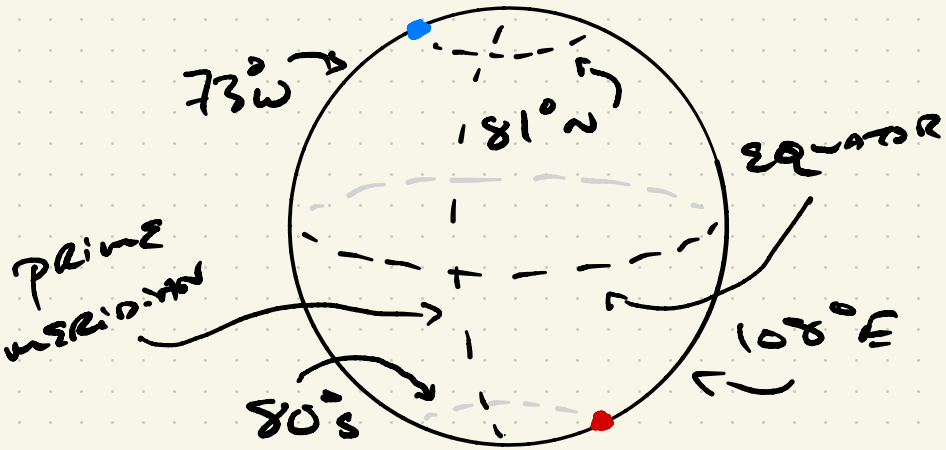
- WHAT WILL HAPPEN TO THE IRON BAR?
  - DOES IT ACQUIRE MAGNETIC POLES? IF SO, WHERE?
- WHAT FORCE DOES IT EXPERIENCE?

(D) FINALLY, TAKE A BAR MAGNET AND A SMALL IRON NEEDLE:

- IF THE NEEDLE IS FREE TO ROTATE BUT CANNOT MOVE, HOW IS IT ORIENTED IN EQUILIBRIUM?

Question 2

- The Earth generates a magnetic field, that, to a good approximation, looks like a Dipole (i.e. the Dipole axis pierces the Earth's surface @
  - 81°N, 73°W (Canada)
  - 80°S, 108°E (Antarctica)



- Austin, TX is located @ 30°N, 98°W

(A) . Add a point for Austin on the diagram on the previous page. Let $98^\circ W \cong 73^\circ W$.

(B) . Superimpose the magnetic field lines of the Earth's magnetic field on the diagram. Make sure one of the lines goes through Austin.

(See next page for hint)

- Hint:
  - PRETEND THERE IS A SMALL BUT VERY STRONG BAR MAGNET @ THE CENTER OF THE EARTH

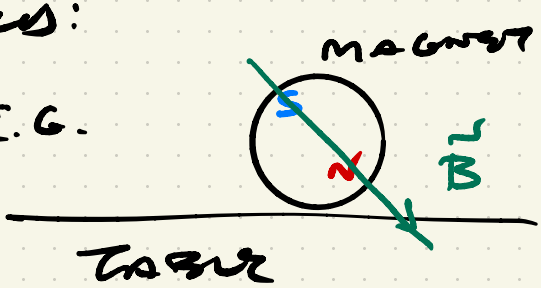
(Question 2c on next page)

C

Q2c

- IMAGINE AT THE TOP OF THE U.T. TOWER YOU LET A SPHERICAL MAGNET ROLL ON A FLAT (LEVEL) TABLE UNTIL IT REACHES EQUILIBRIUM WITH THE EARTH'S MAGNETIC FIELD:

E.G.



NOT NECESSARILY ACCURATE!

(CONT. ON NEXT PAGE)

- USING YOUR ANSWER FROM PART (B):
  - TAKE THE LINE JOINING THE N & S POLES OF THE SPHERICAL MAGNET AND EXTEND IT OUT IN BOTH DIRECTIONS:

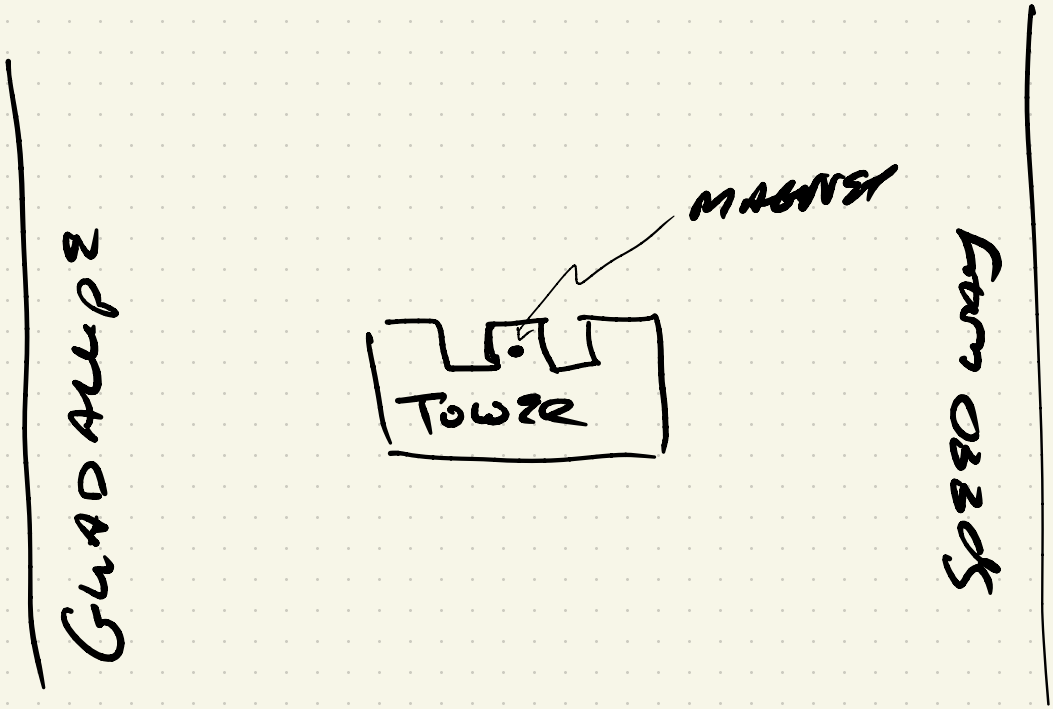
EG. 

(NOT NECESSARILY ACCURATE!)

- WHERE DOES THIS LINE INTERSECT THE GROUND?

(SEE MAP ON NEXT PAGE)

DEAN KEETON



MLK

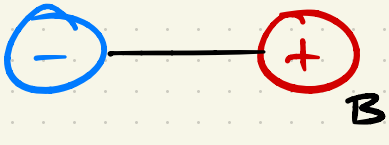
(QUESTION 2D ON NEXT PAGE)

D. Does the line going from the spherical magnet to the intersection point run parallel or anti-parallel to the Earth's magnetic field?

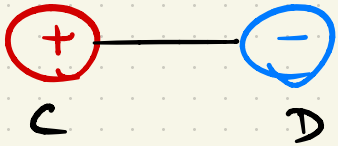
ANSWERS

Dipole "α"

Q1) A)



FIRST METHOD



Dipole "β"

- $\vec{F}_\alpha = \vec{F}_A + \vec{F}_B$

$\vec{F}_A = \vec{F}_{Ac} + \vec{F}_{AD}$

$\vec{F}_B = \vec{F}_{Bc} + \vec{F}_{BD}$

- Focusing on F_A:

$|\vec{F}_{Ac}| > |\vec{F}_{AD}|$ (c is closer to A than D)

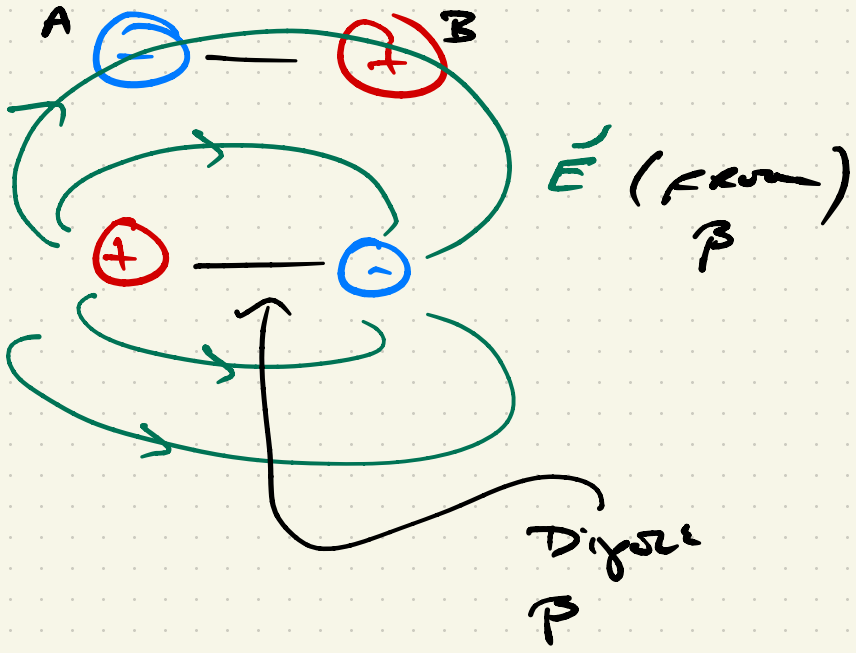
- $\vec{F}_{Ac}$ is ATTRACTIVE

⟶ - $\vec{F}_A$ is ATTRACTIVE

Q1A cont)

- FOR SAME REASON, $\vec{F}_B$ IS ATTRACTIVE, SO
- $\vec{F}_1 = \vec{F}_A + \vec{F}_B$ IS ATTRACTIVE

SECOND METHOD: ✓ Dipole 1



$$\vec{F}_2 = \vec{F}_A + \vec{F}_B$$

$$= \left(-q\vec{E}_A\right) + \left(+q\vec{E}_B\right)$$

$$= -q\left[\nearrow\right] + q\left[\searrow\right]$$

$$= \swarrow + \searrow$$

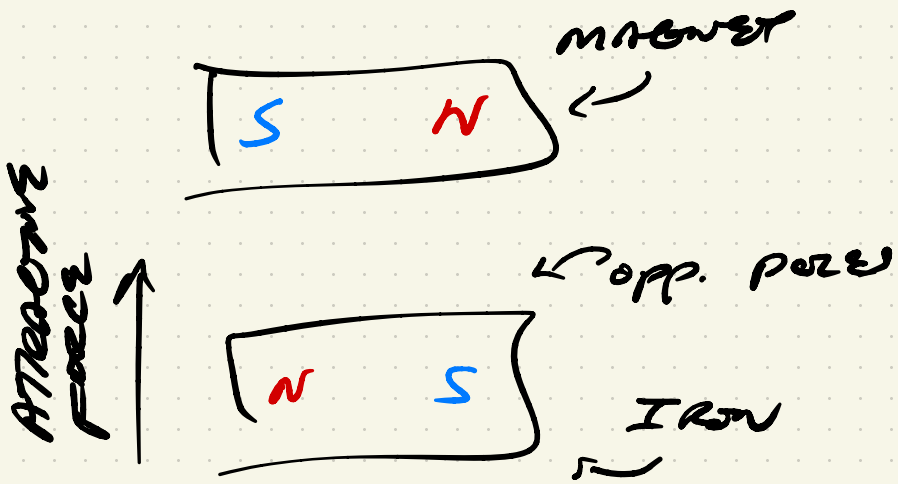
$$= \downarrow$$

ATTRACTIVE

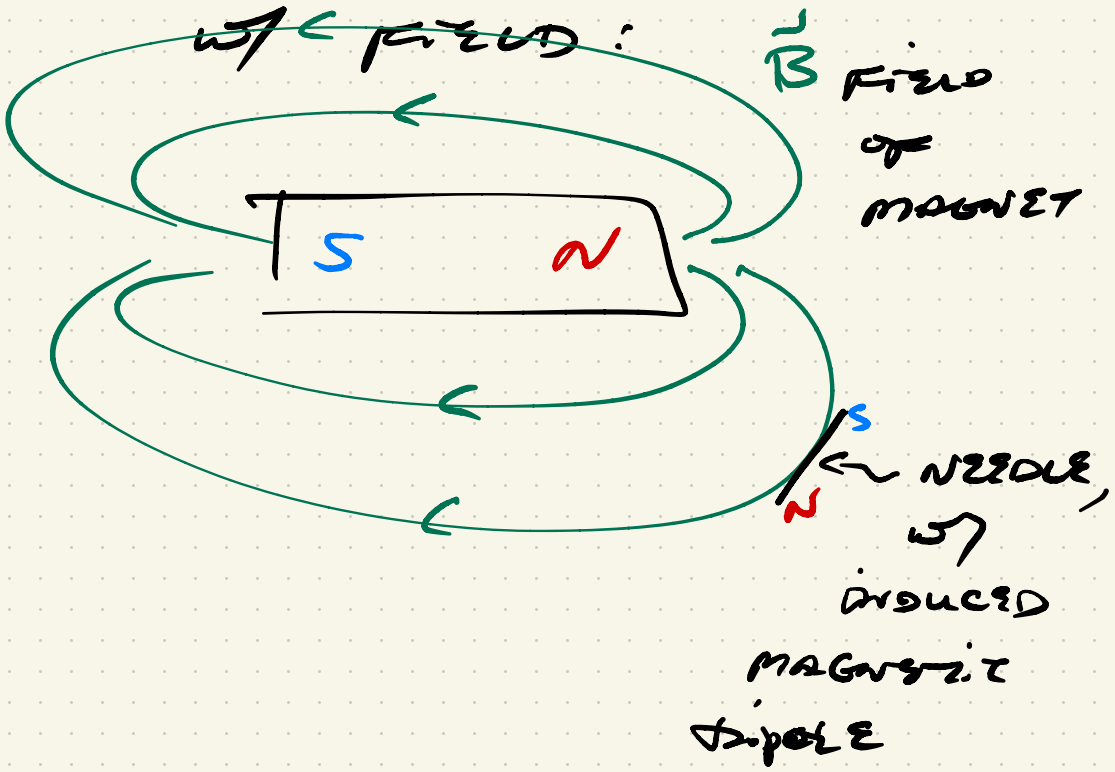
Q1B) OPPOSITE CONCLUSION:

REPULSIVE

Q1C) MAGNETS ATTRACT UNMAGNETIZED IRON, SO MUST INDUCE OPPOSITE POLES (IN LIGHT OF Q1A & Q1B)



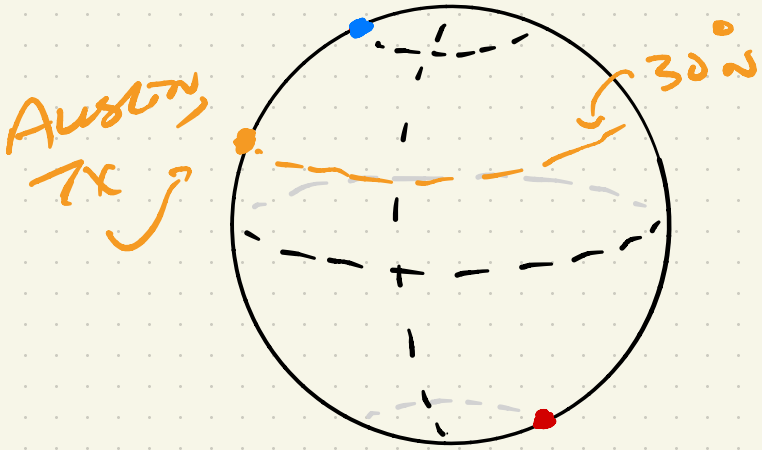
Q1D) MAGNETIC FIELD INDUCES DIPOLE IN NEEDLE, INDUCED DIPOLE ALIGNS W/ FIELD:



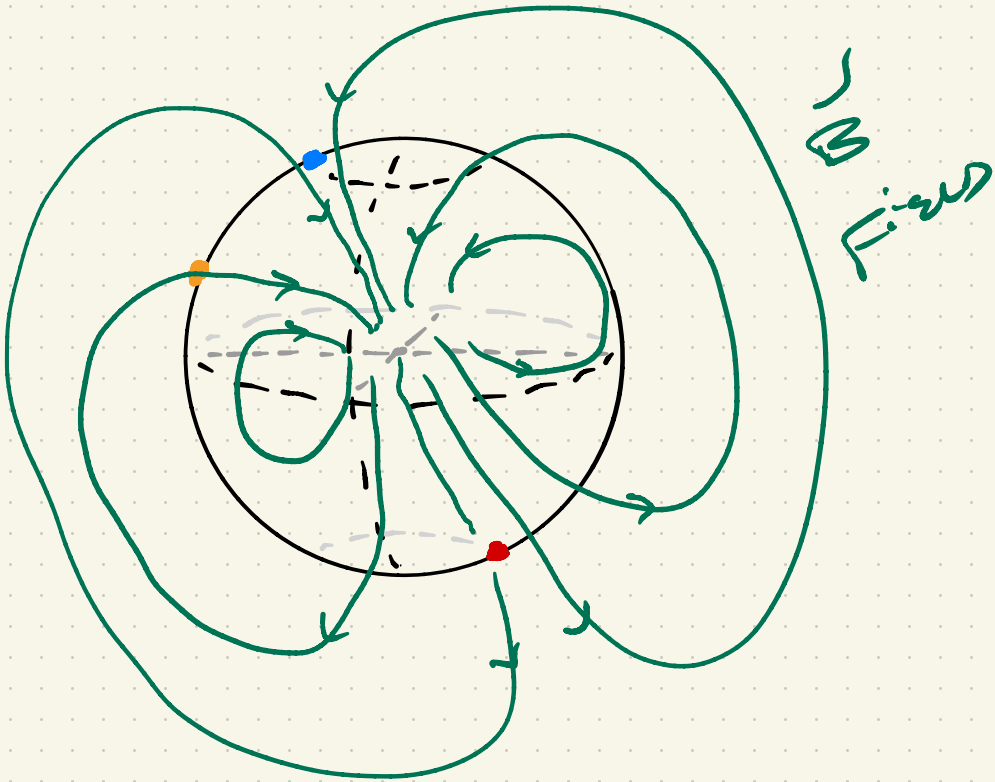
$\vec{B}$ FIELD OF MAGNET

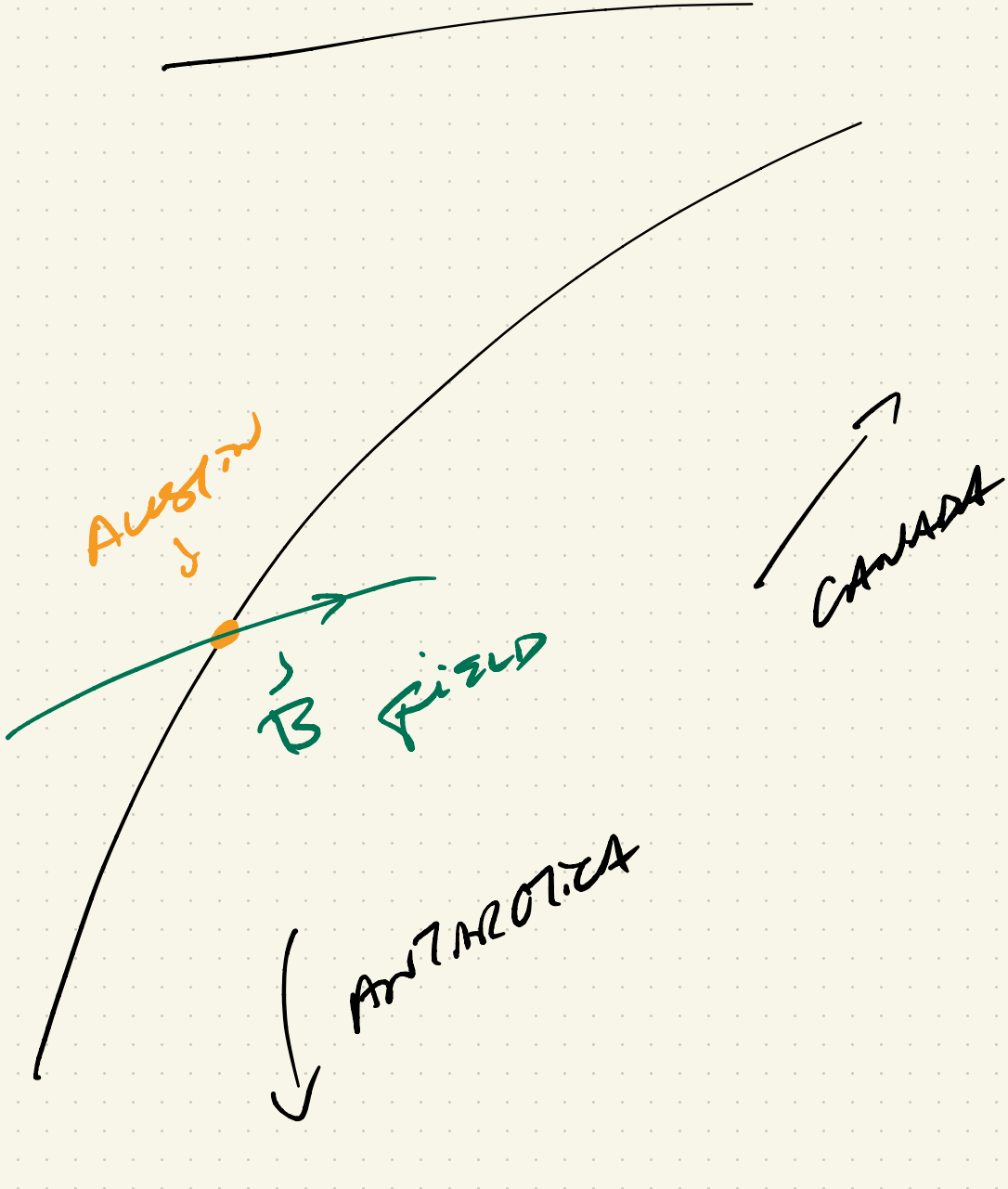
NEEDLE, W/ INDUCED MAGNETIC DIPOLE

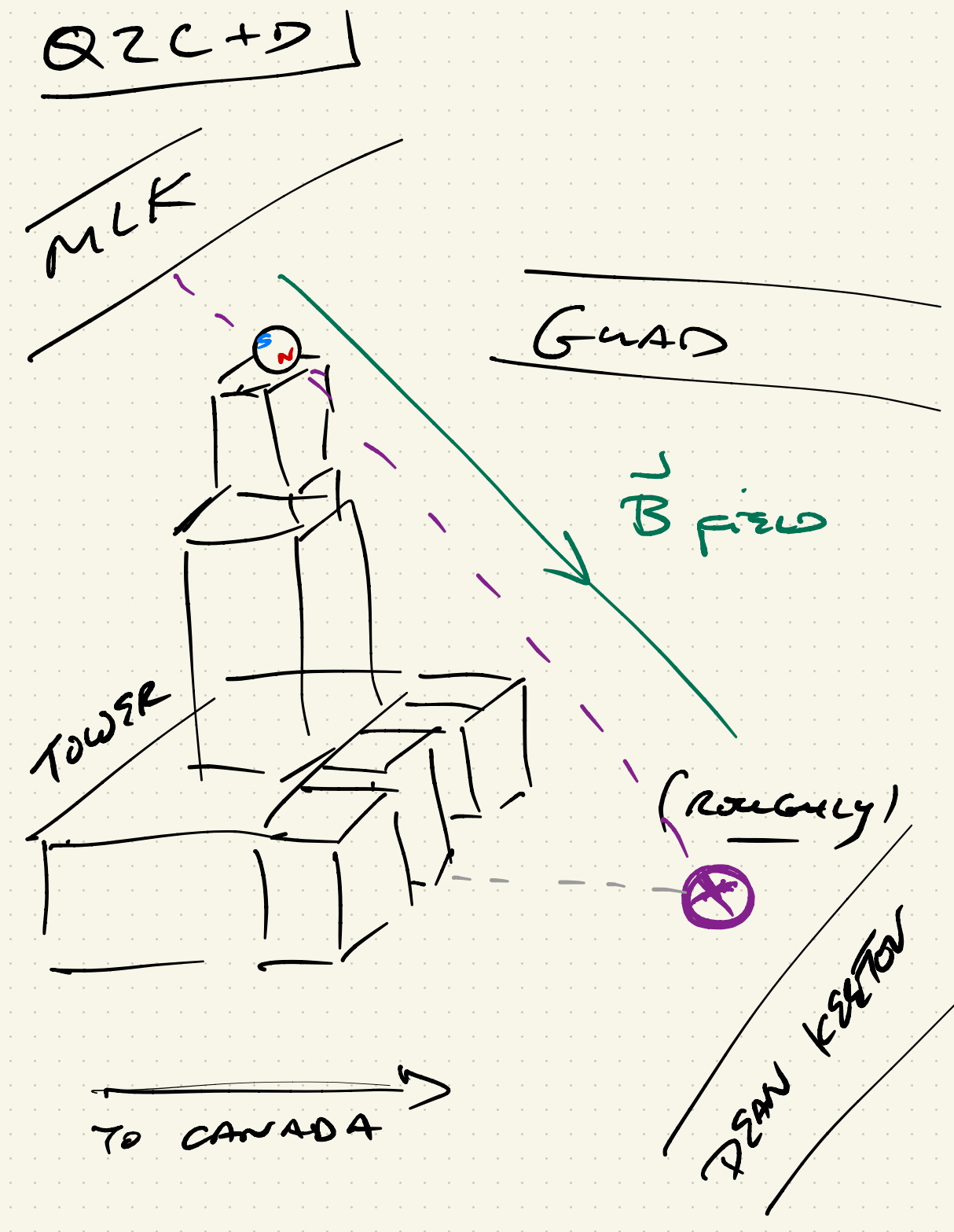
Q2A)



Q2B) GEOGRAPHIC SOUTH POLE IS A MAGNETIC NORTH POLE!




ZOOMED IN
ON AUSTIN:
AUSTIN
B FIELD
CANADA
ANTARCTICA


Q2C+D
MLK
GUAD
B FIELD
TOWER
(ROUGHLY)
DEAN KEETON
TO CANADA