

# Warm-Up for April 6th, 2022

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## 1 Memory Bank and Review from PHYS180

1. Lorentz Force, currents and charges:  $\mathbf{F} = \int I d\mathbf{L} \times \mathbf{B}$  and  $\mathbf{F} = q\mathbf{v} \times \mathbf{B}$
2. Work (mechanics) and centripetal force (mechanics):  $W = \int \mathbf{F} \cdot d\mathbf{r}$  and  $F = mr\omega^2 = mv^2/r$
3. Biot-Savart Law:

$$\mathbf{B} = \frac{\mu_0}{4\pi} \int \frac{I d\mathbf{l}' \times \hat{\mathbf{r}}}{r^2} \quad (1)$$

## 2 Charge, Currents, and Magnetic Fields

1. Consult the situation in Fig. 1. (a) Suppose a particle of charge  $q$  with initial velocity  $\mathbf{v} = v_x\hat{\mathbf{x}} + v_y\hat{\mathbf{y}}$  moves through a constant field  $\mathbf{B} = B\hat{\mathbf{x}}$ . Using  $\omega = 2\pi/T$ , where  $T$  is the period of circular motion in Fig. 1, show that the charge moves in a circle with a frequency  $\omega = (q/m)B$ . (b) Now make the velocity  $\mathbf{v} = v_x\hat{\mathbf{x}} + v_y\hat{\mathbf{y}}$  and explain the trajectory in Fig. 1. (c) Does the  $\mathbf{B}$ -field do work on the charge  $q$ ?
2. Using the Biot-Savart Law, show that the  $\mathbf{B}$ -field at the center of a circular loop of current with radius  $R$  in the  $xy$ -plane centered at the origin is

$$\mathbf{B} = \frac{\mu_0 I}{2R} \hat{\mathbf{z}} \quad (2)$$

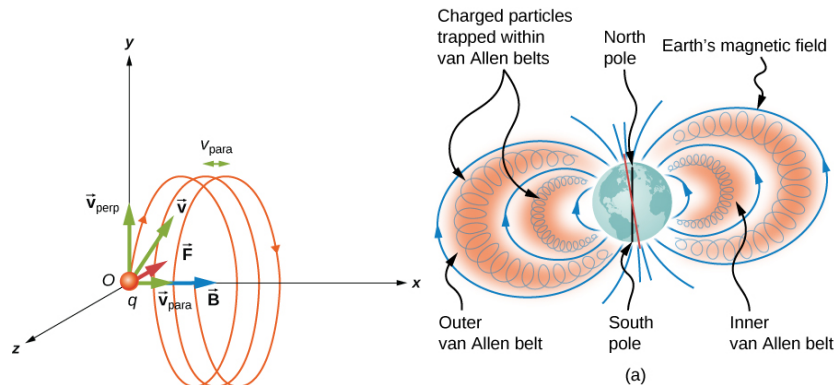


Figure 1: The aurora is caused by Solar cosmic rays interacting with the Earth's magnetic field.