

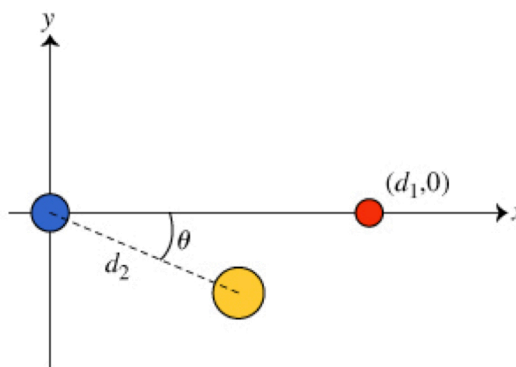
PHYS 234: Recitation 11
(Quiz: Apr 15, 2020)

Potentially useful constants: $k_C = 9 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$.

1. **Estimation:** At what frequency must a hummingbird flap its wings in order to hover? Express your answer in Hz (number of flaps per second). *Clearly state your assumptions and how you came to the numbers you estimate.*

2. **Essay:** Explain the difference between an electric force and an electric field. State whether the electric field is a scalar field or a vector field, and explain why. Give an additional example of (i) a scalar field and (ii) a vector field, from physics or everyday life.

3. Consider the configuration of fixed, uniformly charged spheres in the figure. The blue sphere has positive charge q . The net electric force on the blue sphere is precisely in the $-y$ (downward) direction.



- A. What is the sign of the charge on the yellow sphere?
- B. What is the sign of the charge on the red sphere?
- C. Suppose that the magnitude of the charge on the yellow sphere is determined to be $2q$. Calculate the charge on the red sphere in terms of q , d_1 , d_2 , and θ .

4. Two identical spheres, each of mass m and charge q , are placed in a vertical non-conducting tube. Calculate the height at which the top sphere hovers above the bottom sphere in terms of m , q , Coulomb's constant k_C , and the gravitational acceleration g .



5. Falling raindrops frequently develop electric charges. Suppose two 1 mg drops each have a charge of +30 pC. The centers of the droplets are at the same height and 1 cm apart.

- A. Calculate to one significant figure the magnitude of the electric force between the droplets.
- B. Calculate to one significant figure the magnitude of the gravitational force on one of the droplets, mg .
- C. Which is larger, A or B?