Review Sheet

PHYS 104 (Group ID: 39883)

Dr. Sheren Alsalmi

Fall 2019

How to Solve Problems in Physics?

When taking a qualitative course in physics, like PHYS104, solving problems would be an essential part of your course. In order for you to succeed, you would need to learn some problem-solving skills. If you want to improve your own skills, there are many resources online. However, I have summarized few steps to help make problem-solving easier for you :

1. Have Confidence!

   Always remember, the problem will ask you about something that *you already know*. All you need is to have confidence, organize your thoughts, and follow the next steps.

2. Determine what physical quantities or physical principles are involved.

   For example, when looking at a question you can ask yourself: "Is this question regarding the electric field, or electric flux.. etc?"

3. State the givings and the unknown(s).

4. Make sure that all of your units are in SI units, i.e. N, kg, m, C.

5. Define the formula that will help you calculate the **unknown quantity** based on the problem givings.

   For example, if the problem is asking you to calculate the force, $\vec{F}$, you should figure out what formula to use, i.e. Coulomb's law? $q\vec{E}$? $m\vec{a}$?

6. Make sure that your results are in SI units

7. Don't hesitate to **ask!** You can ask me in class, via email or stop by my office whenever you have a question.

Chapter 23 : Electric Field

- **Electric Force ($\vec{F}$):**

  To calculate the electric force between two charges, we use Coulomb's law:

  $$F_e = k_e \times \frac{q_1 \cdot q_2}{r^2}$$

  Or you can use:

  $$F_e = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 \cdot q_2}{r^2}$$

  where q_1 and q_2 are the two charges (in Coulombs),

  r is the distance between the two charges (in meter),

  k_e Coulomb's constant : 9×10^9 N.m^2/C^2.

- **Electric Field ($\vec{E}$):**

  Calculate the electric field due to a point charge q, we use:

  $$E = k_e \times \frac{q}{r^2}$$

  where q is the source charge of the electric field (in Coulombs),

  r is the distance between the charge q and the point you want to measure the field at(in meter),

  k_e Coulomb's constant : 9×10^9 N.m^2/C^2.

- **Relationship between $\vec{F}$ and $\vec{E}$:**

  If we put a point charge q_0 in a uniform electric field E, the field will apply a force F on the charge:

  $$F = qE$$

- **Calculating $\vec{F}$ and $\vec{E}$ if there were many charges:**

  If we have several forces $\vec{F}_1$, $\vec{F}_2$... and you have been asked to calculate the total force. You need to do two steps:

  1-Calculate the magnitude: Using Coulomb's low:

  $$|F_e| = k_e \times \frac{|q_1| \cdot |q_2|}{r^2}$$

  In this step you don't use the charge signs (only calculate magnitudes of all forces).

  2-Get the direction: By analyzing each resulting force into x-component and y-component, and pay attention to what goes to + or - $\hat{\mathbf{i}}$ and $\hat{\mathbf{j}}$ (+/- x and y).

  $\vec{F}_1 = F_{1x}\,\hat{\mathbf{i}} + F_{1y}\,\hat{\mathbf{j}}$

  $\vec{F}_2 = F_{2x}\,\hat{\mathbf{i}} + F_{2y}\,\hat{\mathbf{j}}$

  3-Calculate the total force: The total force is obtained by summing the x components together, and y components together:

  $\vec{F} = (F_{1x} + F_{2x})\,\hat{\mathbf{i}} + (F_{1y} + F_{2y})\,\hat{\mathbf{j}}$

  $\vec{F} = F_x\,\hat{\mathbf{i}} + F_y\,\hat{\mathbf{j}}$

  The magnitude of the total force is then:

  vector magnitude $= \sqrt{\text{x-component}^2 + \text{y-component}^2}$

  $|F| = \sqrt{F_x^2 + F_y^2}$

The same steps can be done if you have several electric fields $\vec{E}_1$, $\vec{E}_2$ ... and you want to calculate the total electric field $\vec{E}$.

- **Charge moving in a uniform electric field:**

  1-Calculate the charge acceleration: If a charge q with mass m, moves in a uniform electric field $\vec{E}$, the field will apply a force $\vec{F}$ on the charge and will make it accelerate with acceleration $\vec{a}$. The relationship is given by:

  $$\vec{F} = q\vec{E} = m\vec{a}$$

  The acceleration will be calculated as:

  $$\vec{a} = \frac{q\vec{E}}{m}$$

  2-Calculate the position, velocity or time of the charge: If a charge q with mass m, moves in a uniform electric field $\vec{E}$, you can determine the position, velocity and time of the charged particle using the equations of motion:

  $$x_f - x_0 = v_0 t + \frac{1}{2}at^2$$

  $$v_f - v_0 = at$$

  $$v_f^2 - v_0^2 = 2a(x_f - x_0)$$

Chapter 24 : Gauss Law

- **The Electric Flux (Φ_E):**

  1-For an Open Surface:

  $$\Phi_E = \vec{E} \cdot \vec{A}$$
  $$= EA\cos\theta$$

  where A is the area in (m^2), θ is the angle between the electric field lines and the normal vector of the surface.

  2-For a Closed Surface:

  We use Gauss's Law:

  $$\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{Q_{en}}{\epsilon_0}$$

  where Q_{en} is the charge enclosed by the surface (inside the surface).

- **Calculate the electric field using Gauss's law (Applications):**

  1. The electric field due to a point charge:

     $$E = k_e \times \frac{q}{r^2}$$

  2. The electric field due to a charged sphere:

     - Outside the sphere (same as point charge)

     - Inside the sphere:

     $$E = k_e \times \frac{q}{a^3} r$$

     where a is the sphere radius, and r is the point you want to measure the field at.

3. The electric field due to a charged spherical shell:

   - Outside the shell (same as point charge)

   - Inside the sphere: $E = 0$ N/C

4. The electric field due to a charged line:

$$E = 2k_e \times \frac{\lambda}{r}$$

5. The electric field due to a charged plane:

$$E = \frac{\sigma}{2\epsilon_0}$$

6. The electric field of a charged conductor:

   - At the surface of the conductor:

$$E = \frac{\sigma}{\epsilon_0}$$

   - Inside the conductor: $E = 0$ N/C

- **Useful equations for the applications of Gauss law:**

  Charge Distribution Equations:

1. **volume charge density:**

$$\rho \equiv \frac{Q}{V}$$

   ρ: the charge volume density,

   Q: the charge distributed uniformly over a volume V.

2. **surface charge density:**

$$\sigma \equiv \frac{Q}{A}$$

   σ: the charge surface density,

   Q: the charge distributed uniformly over a surface of area A.

3. **linear charge density:**

$$\lambda \equiv \frac{Q}{l}$$

λ: the charge linear density,

Q: the charge distributed uniformly over a line of length l.

"Some" Area and Volume Formulas:

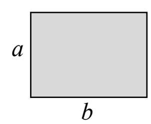
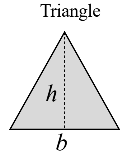
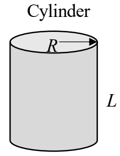
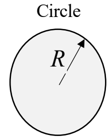
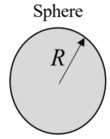
Shape	Area	Volume
Rectangle 	$A = a \times b$	-----
Triangle 	$A = \frac{1}{2} b \times h$	-----
Cylinder 	$A = 2\pi RL$ Surface Area (المساحة الجانبية)	$V = \pi R^2 L$
Circle 	$A = \pi R^2$	----
Sphere 	$A = 4\pi R^2$	$A = \frac{4}{3}\pi R^3$

Figure 1

Chapter 25 : The Electric Potential

- **Charge moving in a uniform electric field**

  (ΔU): If a charge q is moving in an electric field $\vec{E}$, the difference in the potential energy due to moving the charge from a to b (ΔU) is:

  $$\Delta U = U_b - U_a = -q\int_a^b \vec{E}\cdot\vec{ds}$$

  (ΔV): The electric potential difference between a and b

  $$\Delta V = V_b - V_a = -\int_a^b \vec{E}\cdot\vec{ds}$$

- **Important Relationships**

  $$\Delta V = \frac{\Delta U}{q}$$

  $$\text{Work}_{a\to b} = -\Delta U$$

  Note: Both Work and potential energy have the units of energy Joule or electron-volt (J, eV)

- **V and U for Point Charge:**

  - The electric potential (V):

  $$V = k_e \times \frac{q}{r}$$

  - The potential energy (U):

  $$U = k_e \times \frac{qq_0}{r}$$

  Or you can calculate U from V:

  $$U = q_0 V$$