

Physics 272: Practice Problems for Midterm II
There will be 4 problems.
You may bring a calculator and notecard

Problem 1: 25 points

A parallel plate capacitor has plates of area A and separation d and is charged to a potential difference V . *The charging battery is then disconnected, and the plates are pulled apart until their separation is $3d$.*

- a) Find the new potential difference in terms of A , d and V .
- b) Find the initial and final stored energy in terms of A , d , and V .
- c) Find the work required to separate the plates in terms of A , d , and V .

Problem 2: 25 points

Find the currents in the circuit. The elements have the following values, $\mathcal{E}_1 = 2.1 \text{ V}$, $\mathcal{E}_2 = 6.3 \text{ V}$, $R_1 = 1.7 \Omega$, $R_2 = 3.5 \Omega$. The batteries in the circuit have negligible internal resistance.

Problem 3: 25 points

A $1000\ \Omega$ resistor is rated at 2 W.

- a) What is the maximum current allowed through this resistor ?
- b) If this maximum current exists in the $1\ \text{k}\Omega$ resistor for 5 minutes, how many coulombs pass through this resistor in this time ?
- c) How many electrons pass through any cross-section of the resistor in this time ?

Problem 4: 25 points

Suppose that a region of space contains uniform electric and magnetic fields of unknown direction and magnitude. In order to measure these fields a test charge $Q = 10^{-6}$ C is used. The following measurements are made:

- (1) At rest, the test charge experiences a force of $\vec{F} = 10 \times 10^{-5}$ N in the direction of the positive y-axis.
- (2) Moving at a speed of $v = 20$ m/s in the positive y direction, the charge experiences a force given by $F = (10\hat{j} - 2\hat{k}) \times 10^{-5}$ N.
- (3) Moving with the same speed in the positive z direction, the force is $\vec{F} = (-\hat{i} + 12\hat{j}) \times 10^{-5}$ N.

Find the electric and magnetic fields in component form.

Problem 5: 25 points

Consider the circuit shown below.

- a) What is the initial current just after the switch is closed ?
- b) What is the steady state current through the battery after the switch is closed a long time ?

Problem 6: 25 points

An electron moves with a velocity of 3.75×10^6 m/s in the x-y plane at an angle of 60° to the x-axis and 30° to the y-axis. There is a magnetic field of 0.85 T in the positive y-direction.

- (a) What is the force on the electron in component form ?
- (b) If we now turn on an electric field, what electric field would be required for the net force on the electron to be zero ?

Problem 7: 25 points

(a) A heater consists of a variable resistance connected across a constant voltage supply. To increase the *heat output* should you decrease the resistance or increase it ? **Explain your choice.**

(b) A capacitor is discharging through a resistor. If it takes a time T for the charge on the capacitor to drop to half of its initial value, how long does it take for the energy to drop to half its initial value ?

(c) A proton with charge $+e$ is moving with a speed v at 50° to the direction of the magnetic field \vec{B} . What is the component of the force on the proton *in the direction of \vec{B}* ?

(d) A porcelain slab ($\kappa = 6.5$) is inserted between the plates of a 13.5 pF parallel plate capacitor. What is the new capacitance ?

(e) Explain how a *mass spectrometer* is used to separate isotopes of different materials.

(f) What is the *Hall effect* and why is it useful ?