

# PHYS 2220: Physics for Scientists and Engineers II



## Course Description

Second semester of a two semester sequence in calculus-based physics. This semester covers topics in electricity and magnetism, electromagnetic waves, light and optics, relativity, and quantum, atomic, and nuclear physics. The second semester of Physics for Scientists and Engineers starts with a description of the basic properties and sources of electric and magnetic fields. Maxwell's equations are then used to study the properties of electromagnetic waves. The course then examines the nature of light, the special theory of relativity, quantum physics, and atomic and nuclear physics.

## Prerequisites/Co-requisites

Math 1220 (co-requisite), PHYS 2229 (3-hour lab), PHYS 2210 (pre-requisite)

## General Information

Class Times	LL 121, 9:30 AM Monday - Friday
Required Texts	Physics for Scientist and Engineers, 2nd Edition, Knight
Instructor	John Armstrong
Office Hours	SL 205, 11:30 AM - 12:30 PM, MW, or by appointment
Email	<a href="mailto:jcarmstrong@weber.edu">jcarmstrong@weber.edu</a>
Web	<a href="http://weber.edu/jcarmstrong">http://weber.edu/jcarmstrong</a>
Phone	801.626.6215

## Course Philosophy

This course has two main goals:

1. Survey the physical laws and phenomena that describe the nature of the Universe
2. Develop a method for studying the world that is based on experimental verification and problem solving

You will find that physics is embedded in everything we see and do, from driving our cars and cooking dinner to probing the fundamental nature of matter. But physics is more than a body of knowledge. It is a method for exploring and understanding the way the world works. When you are done with this course, you will possess a full range of valuable analytical problem solving skills. You will also learn that the Universe is comprehensible, not only by some scientist, but by **you**.

## Succeeding in Class

This course, and the materials in the course, are designed to help you learn physics. Like any complex mental activity, physics requires study and practice. Lucky for you, physics is also really fun! To succeed, you should take full advantage of the materials available. I recommend that you:

1. Prepare for class by reviewing the reading assignment. These are short reading assignments prior to each class to get you thinking about the discussion topics.

# PHYS 2220: Physics for Scientists and Engineers II

2. Actively engage through class participation. We will be practicing physics in class through demonstrations, simulations, and experiments. Read your text and come prepared to participate.
3. Practice what you have learned through the workbook exercises.
4. Re-read the reading assignment.
5. Hone your problem solving skills through homework problems.
6. Assess what you have learned with in-class exams.

## Mastering Physics

All of our weekly assignments will be on Mastering Physics, due at 11:59 PM on Wednesday night, when the next homework is assigned. Late submissions will not be accepted (since I will be posting solutions on Thursday morning). All of the assignments in this class will be performed online, using the Mastering Physics Website:

<http://www.masteringphysics.com>

This course will be using the Mastering Physics web resources supplied with your textbook. If you purchased a used textbook, you can purchase a subscription with a credit card on the web site. This is required for the course, as your Mastering Physics assignments will be recorded under your name in the online gradebook. The name of your course is: **ARMSTRONGPHYS2220SP10**. You will need this to register for our course on line.

## Exams

There will be five equally weighted exams during the course. These serve as a measure of your 'retained' knowledge and will help you (and me) keep tabs on your progress. If you must miss an exam due to a prior commitment, you must make arrangements **in advance**. Makeup exams will not be given except under the most extreme circumstances. All exams will be held in LL 121 on the dates indicated.

## Lab

Lab is a required component of this course, and you must be enrolled in a lab section. I will be doing my best to coordinate our schedule with the one in your lab, but be aware that some weeks we will cover topics after or before you cover them in lab.

## Grading Policy

Your grade will be compiled from homework, labs, and exams according to the following:

Mastering Physics	40%
Exams (5 exams @ 8% each)	40%
Lab Reports (Average from lab)	17%
Lab Final	3%

## **Attendance Policy**

While I will not be taking attendance in class, you are encouraged to attend regularly. This is going to be an awesome, exciting class, so why would you want to be anywhere else?

## **Academic Integrity**

Regarding academic integrity, I will enforce policies as laid down in Section IV:D of the Student Responsibilities outlined in the Student Code. Specifically, no cheating or other forms of academic dishonesty will be tolerated. The first instance of cheating will result in a zero on that assignment. The second instance will result in failing the class. You will be working in groups occasionally, however, so you will be required to distinguish the difference between collaboration and cheating. When in doubt, make sure to give credit where credit is due.

## **Special Accommodations**

Any students requiring accommodations or services due to a disability must contact Services for Students with Disabilities (SSD) in room 181 of the Student Service Center. SSD can also arrange to provide course materials (including this syllabus) in alternative formats if necessary.

## Schedule subject to change

Date	Topics	Monday	Tuesday	Weds	Thursday	Friday
1/4	Introduction Waves Review Wave Optics	Intro Review	21.5-21.8	22.1-22.2	22.3-22.4	22.4-22.6
1/11	Ray Optics Electrical Charge and Forces	23.1-23.2	23.3-23.4	23.5-23.6	23.7-23.8	26.1-26.2
1/18	Electrical Charge and Forces	<b>MLK Day</b>	26.3-26.4	26.5	<b>Review</b>	<b>Exam 1</b>
1/25	The Electric Field The Electric Potential	27.1-27.2	27.3-27.5	27.6-27.7	29.1-29.4	29.5-29.7
2/1	Potential and Field Current and Resistance]	30.1-30.3	30.4-30.5	30.6-30.7	31.1-31.3	31.4-31.5
2/8	Fundamentals of Circuits	32.1-32.2	32.3-32.6	32.7-32.9	<b>Review</b>	<b>Exam 2</b>
2/15	The Magnetic Field	<b>Prez Day</b>	33.1-33.3	33.4-33.6	33.7-33.8	33.9-33.10
2/22	Induction E&M Fields and Waves	34.1-34.3	34.4-34.7	34.8-34.10	35.1-35.3	35.4-35.5
3/1	E&M Fields and Waves AC Circuits	35.6-35.7	36.1-36.2	36.3-36.6	<b>Review</b>	<b>Exam 3</b>
3/8	Relativity	37.1-37.2	37.3-37.4	37.5-37.6	37.7-37.8	37.9-37.10
3/15	<b>Spring Break</b>					
3/22	The End of Classical Physics Quantization	38.1-38.4	38.5-38.9	39.1-39.3	39.4-39.5	39.6-39.7
3/29	Wave Functions and Uncertainty	40.1-40.2	40.3-40.4	40.5-40.6	<b>Review</b>	<b>Exam 4</b>
4/5	One-D Quantum Mechanics Atomic Physics	41.1-41.2	41.3-41.4	41.5-41.7	41.8-41.10	42.1-42.3
4/12	Atomic Physics Nuclear Physics	42.4-42.5	42.6-42.8	43.1-43.2	43.3-43.5	43.6-43.7
4/19	Review	<b>Review</b>	<b>FINAL in the Testing Center</b>			

Name \_\_\_\_\_

## Exam I

Physics 2220  
Armstrong

Spring 2010

This is Exam I for PHYS 2220. There are five equally weighted questions and you have 50 minutes to complete the exam. You may use a calculator, your 3x5 prepared card, **but no other materials are allowed**. Please write your answers on the sheets provided. Have fun!

Some useful constants:

$$\begin{aligned}\epsilon_0 &= 8.85 \times 10^{-12} \frac{C^2}{N m^2} \\ e &= 1.60 \times 10^{-19} C\end{aligned}$$

1. Two sources of light illuminate a double slit simultaneously. One has wavelength 570 nm and the second has an unknown wavelength. The  $m = 5$  bright fringe of the unknown wavelength overlaps the  $m = 4$  bright fringe of the light of 570 nm wavelength. What is the unknown wavelength?

2. (a) An object is 20 cm in front of a converging lens with a focal length of 10 cm. Use ray tracing to determine the location of the image. Is it upright or inverted?

(b) Compute the image height and image distance from the lens.

3. A fisherman in a stream 40 cm deep looks downward into the water and sees a rock on the stream bed. How deep does the stream appear to the fisherman? Assume that the index of refraction of the water is 1.33.

4. The figure shows two 5.0 g spheres suspended from 1.0-m-long threads. The spheres repel each other after being charged to +90 nC. What is the angle  $\theta$ ?



5. In the figure below the charge in the middle is  $Q = -3.1 \text{ nC}$ .

(a) For what charge  $q_1$  will charge  $q_2$  be in static equilibrium?

(b) Draw the electric field of the resulting configuration below:

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## Exam II

Physics 2220  
Armstrong

Spring 2010

This is Exam II for PHYS 2220. There are five equally weighted questions. You may use a calculator, your 3x5 prepared card, **but no other materials are allowed**. Please write your answers on the sheets provided. Have fun!

Some useful constants:

$$\begin{aligned}\epsilon_0 &= 8.85 \times 10^{-12} \frac{C^2}{N m^2} \\ e &= 1.60 \times 10^{-19} C\end{aligned}$$

1. What are the charge on and the potential difference across each capacitor in the figure below?

2. (a) Draw a circuit with a battery connected to four resistors,  $R_1 = 100 \Omega$ ,  $R_2 = 100 \Omega$ ,  $R_3 = 300 \Omega$ , and  $R_4 = 200 \Omega$ . Resistors  $R_1$  and  $R_2$  are connected in parallel, resistors  $R_3$  and  $R_4$  are connected in parallel, and both parallel pairs of resistors are connected in series. What is the total resistance of the circuit?

3. Consider the group of charges in this figure. All three charges have  $Q = 2.4 \text{ nC}$ .

(a) What is their electric potential energy?

(b) What is the electric field at the point labeled "a"?

4. A proton is fired with a speed of  $200,000 \text{ m/s}$  from the midpoint of a capacitor toward the positive plate. Does the proton reach the positive plate of the capacitor?

5. (a) A fuse “blows” if the current exceeds 1.0 A. It is made of material that melts at a current density of  $620 \text{ A/cm}^2$ . What is the diameter of the wire in the fuse?

(b) Using the fuse from part (a), you create the circuit below with an EMF, a 100 W light bulb, and the fuse. How high can the EMF be before the fuse blows? Assume the fuse has no internal resistance and that the light bulb has a rated resistance of  $140 \Omega$ .

Name \_\_\_\_\_

### Exam III

Physics 2220  
Armstrong

Spring 2010

This is Exam III for PHYS 2220. There are five equally weighted questions. This exam is designed for 50 minutes, but you have no fixed time limit on this exam in the testing center. You may use a calculator, your 3x5 prepared card, **but no other materials are allowed**. Please write your answers on the sheets provided. Have fun!

Some useful constants:

$$\begin{aligned}\epsilon_0 &= 8.85 \times 10^{-12} \frac{C^2}{N m^2} \\ \mu_0 &= 1.26 \times 10^{-6} \frac{T m}{A} \\ e &= 1.60 \times 10^{-19} C\end{aligned}$$

1. A wire is formed into a circle with radius 10 mm. A current flows through the wire and causes a magnetic field of magnitude  $B$  at the center of the loop. If the wire is heated such that the circumference of the loop expands by 10%, what does the magnitude of the magnetic field become at the center of the loop? Write your answer in terms of the original magnetic field.

2. A circular conducting loop with a radius of 1.0 m and a small gap filled with a  $10\ \Omega$  resistor is oriented in the xy-plane. If a magnetic field of 3.0 T pointing in the +z direction and making an angle of  $30^\circ$  with the z-axis increases to 10.0 T in 3.0 s, what is the magnitude and direction of the current that will be caused to flow in the conductor?



3. The magnitude of a magnetic field a distance  $2.0 \mu\text{m}$  from a wire is  $1.0 \times 10^{-3} \text{ T}$ . How much current is flowing through the wire? Assume the wire is the only contributor to the magnetic field.

4. A proton passes through a parallel plate capacitor (with  $\vec{E} = 1.0 \times 10^5 \text{ V/m}$ , pointing down) with a speed of  $1.0 \times 10^6 \text{ m/s}$ .

(a) What magnetic field  $\vec{B}$ , both magnitude and direction, must be applied to allow the proton to pass through the capacitor with no change in speed or direction?

(b) Find the electric and magnetic fields (magnitude and direction) in the proton's reference frame.

5. An AM radio station is assigned a frequency range from 920 kHz to 940 kHz. A tuner in the form of an RLC circuit in a radio receiver resonates in the middle of this frequency range. The circuit uses a 33 pF capacitor. What is the value of the inductor for the circuit?

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### Exam IV

Physics 2220  
Armstrong

Spring 2010

This is Exam IV for PHYS 2220. There are five equally weighted questions. You may use a calculator, your 3x5 prepared card, **but no other materials are allowed**. Please write your answers on the sheets provided. Have fun!

Some useful constants:

$$\begin{aligned}\epsilon_0 &= 8.85 \times 10^{-12} \frac{C^2}{N m^2} \\ e &= 1.60 \times 10^{-19} C \\ m_e &= 9.11 \times 10^{-31} kg \\ 1 eV &= 1.60 \times 10^{-19} J \\ h &= 6.63 \times 10^{-34} J s\end{aligned}$$

1. In their common rest frame, two stars are 90.0 ly apart. If they appear to be 12.0 ly apart to a spaceship, how fast is the spaceship moving? Express your answer in terms of  $c$ .

2. Han Solo and Greedo sit one meter apart having an argument in the Cantina. Both shoot their blasters, and Greedo ends up dead. As lead investigator of *CSI: Tatooine*, you survey the crime scene and query the event logs on both blasters. According to the records, Han shot his blaster  $1.0 \text{ ns}$  before Greedo. During the argument, Chewbacca flies by in the Millennium Falcon at  $0.9 c$ .

(a) Use the Lorentz transformations to compute the time when Han shot and the time when Greedo shot from Chewie's perspective.

(b) From Chewie's perspective, who shot first?

(c) Who's right, the cops or Chewie?

3. In a photoelectric-effect experiment electrons emerge from a copper surface (work function 4.65 eV) with a maximum kinetic energy of 1.10 eV. What is the wavelength of the light?

4. You toss a coin 3 times. What is the probability of getting at least 2 heads? Show your reasoning.

5. An electron confined to a 1-D box is observed, at different times, to have energies of 12, 27, and 48 eV. What is the length of the box?



Name \_\_\_\_\_

### Exam V

Physics 2220  
Armstrong

Spring 2010

This is Exam V for PHYS 2220. There are five equally weighted questions. You may use a calculator, your 3x5 prepared card, **but no other materials are allowed**. Please write your answers on the sheets provided. Have fun!

Some useful constants:

$$\begin{aligned}\epsilon_0 &= 8.85 \times 10^{-12} \frac{C^2}{N m^2} \\ e &= 1.60 \times 10^{-19} C \\ m_e &= 9.11 \times 10^{-31} kg \\ 1 eV &= 1.60 \times 10^{-19} J \\ h &= 6.63 \times 10^{-34} J s \\ u &= 1.6605 \times 10^{-27} kg\end{aligned}$$

1. (20 points) An electron is trapped in an infinite square well of width 10.0 nm. Find the wavelength of photons emitted when the electron drops from the  $n = 5$  state to the  $n = 1$  state in this system.

2. (20 points) The 1-D time independent Schrödinger Equation,

$$\frac{d^2\psi}{dx^2} = \frac{2M}{\hbar^2} [U(x) - E] \psi \quad (1)$$

allows us to determine the wave function for a given system.

(a) In general terms, what *is* a matter wave function?

(b) What does the matter wave function tell us?

(c) List the steps require to solve the Schrödinger Equation for a given system. That is, what do you need to know, what steps do you need to take, what are you trying to find out?

3. (20 points) You are sitting in your lawn chair one summer day, playing with your new GPS receiver in preparation for a big hiking trip. Suddenly, you remember the uncertainty principle from physics class, and get a little worried that your own quantum nature will get you lost next time you are in the woods!

(a) Assuming your GPS has an accuracy of 1 meter, determine the uncertainty in your momentum.

(b) What is the corresponding uncertainty in your velocity (state your assumptions)?

(c) At this speed, how far will you move over the age of the Universe (13 billion years)?

(d) Are you still worried that your quantum ‘uncertainty’ will ruin your backpacking trip?

4. (20 points) Playing with quantum numbers (show your reasoning):

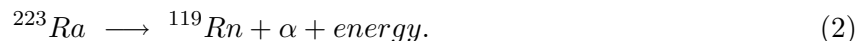
(a) How many possible quantum states exist for an electron in the  $n=5$ ,  $l=4$  excited hydrogen atom?

(b) What is the greatest magnitude of the orbital angular momentum  $L$  that you can find in a state with  $n = 5$ ?

(c) What is the greatest total angular momentum  $j$  for an electron in the  $n = 2$  orbit?

(d) How many electrons can be found with principal quantum number  $n = 3$  in a suitably heavy atom?

5. The radium isotope  $^{223}\text{Ra}$  (with mass  $223.018499\text{ u}$  and half life  $11.43$  days) decays to the radon isotope  $^{219}\text{Rn}$  (with mass  $219.009477\text{ u}$ ) by emitting an alpha particle (with mass  $4.002606\text{ u}$ ),



You happen to have a 1 gram cube of radium and decide to boil some water for tea. You fill a well insulated container with 100 mL of water at  $18^\circ\text{C}$  and drop in the cube of radium.

- (a) What is the total energy released per reaction, in Joules?

- (b) How many reactions are necessary to heat the water to the boiling point (assume water has a specific heat of  $4186 \frac{\text{J}}{\text{kg K}}$ )? Calculate this as a fraction of the total number of radium atoms in the sample.

- (c) How long does it take to heat up the water?

- (d) Is this a good idea? *Answer: No.*

[Student View](#)[Summary View](#)[Diagnostics View](#)[Print View with Answers](#)[ment](#)[Settings per Student](#)

## Assignment 5

[\[ Print \]](#)

Due: 11:59pm on Wednesday, February 11, 2009

**Note:** You will receive no credit for late submissions. To learn more, read your instructor's [Grading Policy](#)

### Problem 29.36

**Description:** A  $-2.0$  nC charge and a  $2.0$  nC charge are located on the  $x$ -axis at  $x = -1.0$  cm and  $x = +1.0$  cm, respectively. (a) At what position or positions on the  $x$ -axis is the electric field zero? (b) At what position or positions on the  $x$ -axis is the electric...

A  $-2.0$  nC charge and a  $2.0$  nC charge are located on the  $x$ -axis at  $x = -1.0$  cm and  $x = +1.0$  cm, respectively.

Part A

At what position or positions on the  $x$ -axis is the electric field zero?

ANSWER:

- $x = +2.0$  cm  
  $x = -2.0$  cm  
  $x = 0$   
  $x = \pm \infty$

Part B

At what position or positions on the  $x$ -axis is the electric potential zero?

ANSWER:

- $x = -2.0$  cm  
  $x = +\infty$   
  $x = +2.0$  cm  
  $x = 0, \pm \infty$

### Problem 29.38

**Description:** Two  $m_1$  beads, each charged to  $q_1$ , are  $l$  apart. A  $m_2$  bead charged to  $q_2$  is exactly halfway between them. The beads are released from rest. (a) What is the speed of the positive beads, in

cm/s, when they are very far apart?

Two 1.3 g beads, each charged to 5.5 nC, are 2.1 cm apart. A 2.6 g bead charged to -1.2 nC is exactly halfway between them. The beads are released from rest.

Part A

What is the speed of the positive beads, in cm/s, when they are very far apart?

**Express your answer using two significant figures.**

ANSWER:

$$v = \sqrt{\frac{9.0 \cdot 10^9 \left( \frac{2q_1 q_2}{\frac{1}{2}} + \frac{q_1^2}{l} \right)}{m_1 \cdot 10^{-3}}} \cdot 100 \quad \text{cm/s}$$

3.6

### Problem 29.40

**Description:** Two small metal spheres with masses 2.0 g and 4.0 g are tied together by a r-cm-long massless string and are at rest on a frictionless surface. Each is charged to +Q. (a) What is the energy of this system? (b) What is the tension in the string? (c) ...

Two small metal spheres with masses 2.0 g and 4.0 g are tied together by a 5.0-cm-long massless string and are at rest on a frictionless surface. Each is charged to +2.2 μC.

Part A

What is the energy of this system?

**Express your answer using two significant figures.**

ANSWER:

$$E_0 = \frac{9.0 \cdot 10^9 Q^2}{r} \quad \text{J}$$

0.87

Part B

What is the tension in the string?

**Express your answer using two significant figures.**

ANSWER:

$$T = \frac{9.0 \cdot 10^9 Q^2}{r^2} \quad \text{N}$$

17

## Part C

The string is cut. What is the speed of each sphere when they are far apart?

**Hint:** There are two conserved quantities. Make use of both.

**Express your answers using two significant figures. Enter your answers numerically separated by a comma.**

ANSWER:

$$v_1, v_2 = \sqrt{\frac{\frac{2.4}{6} \cdot 9.0 \cdot 10^{12} Q^2}{r}}$$

$$\sqrt{\frac{\frac{2.2}{6} \cdot 9.0 \cdot 10^{12} Q^2}{r}}$$

$$\sqrt{\frac{\frac{2.2}{6} \cdot 9.0 \cdot 10^{12} Q^2}{r}} \quad \text{m/s}$$

$$\sqrt{\frac{\frac{2.4}{6} \cdot 9.0 \cdot 10^{12} Q^2}{r}}$$

**24,12**

### Problem 29.46

**Description:** The electron gun in a TV picture tube accelerates electrons between two parallel plates  $d$  apart with a  $\Delta V$  potential difference between them. The electrons enter through a small hole in the negative plate, accelerate, then exit through a small hole ...

The electron gun in a TV picture tube accelerates electrons between two parallel plates 1.3 **cm** apart with a 21 **kV** potential difference between them. The electrons enter through a small hole in the negative plate, accelerate, then exit through a small hole in the positive plate. Assume that the holes are small enough not to affect the electric field or potential.

## Part A

What is the electric field strength between the plates?

**Express your answer using two significant figures.**

ANSWER:

$$E = \frac{\Delta V}{d} \quad \text{N/C}$$



$1.6 \times 10^6$ 

## Part B

With what speed does an electron exit the electron gun if its entry speed is close to zero? Note: the exit speed is so fast that we really need to use the theory of relativity to compute an accurate value. Your answer to part B is in the right range but a little too big.

**Express your answer using two significant figures.**

ANSWER:

$$v_{\text{exit}} = \sqrt{\frac{2\Delta V \cdot 1.6 \cdot 10^{-19}}{9.11 \cdot 10^{-31}}} \quad \text{m/s}$$

 $8.6 \times 10^7$ 

### Problem 29.58

**Description:** The sun is powered by fusion, with four protons fusing together to form a helium nucleus (two of the protons turn into neutrons) and, in the process, releasing a large amount of thermal energy. The process happens in several steps, not all at once. In ...

The sun is powered by *fusion*, with four protons fusing together to form a helium nucleus (two of the protons turn into neutrons) and, in the process, releasing a large amount of thermal energy. The process happens in several steps, not all at once. In one step, two protons fuse together, with one proton then becoming a neutron, to form the "heavy hydrogen" isotope *deuterium* ( ${}^2\text{H}$ ). A proton is essentially a 2.4-fm-diameter sphere of charge, and fusion occurs only if two protons come into contact with each other. This requires extraordinarily high temperatures due to the strong repulsion between the protons. Recall that the average kinetic energy of a gas particle is  $\frac{3}{2} k_B T$ .

## Part A

Suppose two protons, each with exactly the average kinetic energy, have a head-on collision. What is the minimum temperature for fusion to occur?

**Express your answer using two significant figures.**

ANSWER:

$$T_{\text{min}} = \frac{2.3 \cdot 10^9}{2.3 \times 10^9} \quad \text{K}$$

## Part B

Your answer to part a is much hotter than the 15 million K in the core of the sun. If the temperature were as high as you calculated, every proton in the sun would fuse almost instantly and the sun would explode. For the sun to last for billions of years, fusion can occur only in collisions between two protons with kinetic

energies much higher than average. Only a very tiny fraction of the protons have enough kinetic energy to fuse when they collide, but that fraction is enough to keep the sun going. Suppose two protons with the same kinetic energy collide head-on and just barely manage to fuse. By what factor does each proton's energy exceed the average kinetic energy at 15 million K?

**Express your answer using three significant figures.**

ANSWER:

$$\frac{E_1}{E_2} = \frac{153}{153}$$

### Problem 30.38

**Description:** The electric field in a region of space is  $E_x = 5000x$  V/m, where  $x$  is in meters. (a) Graph  $E_x$  versus  $x$  over the region  $-1 \text{ m} \leq x \leq 1 \text{ m}$ . (b) Find an expression for the potential  $V$  at position  $x$ . As a reference, let  $V=0$  V at the origin. (c)...

The electric field in a region of space is  $E_x = 5000x$  V/m, where  $x$  is in meters.

Part A

Graph  $E_x$  versus  $x$  over the region  $-1 \text{ m} \leq x \leq 1 \text{ m}$ .

ANSWER:

[View](#)

Part B

Find an expression for the potential  $V$  at position  $x$ . As a reference, let  $V = 0$  V at the origin.

**Express your answer in terms of  $x$ .**

ANSWER:

$$V(x) = -2500x^2 \text{ V}$$

Part C

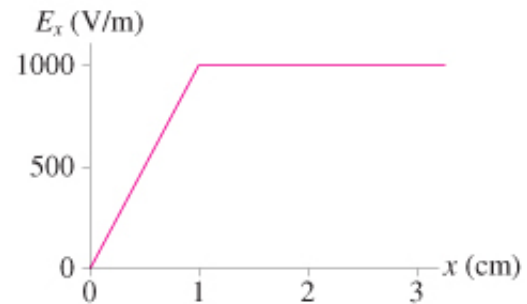
Graph  $V$  versus  $x$  over the region  $-1 \text{ m} \leq x \leq 1 \text{ m}$ .

ANSWER:

[View](#)**Problem 30.40**

**Description:** The figure shows  $E_x$ , the  $x$ -component of the electric field, as a function of position along the  $x$ -axis. (a) Graph  $V$  versus  $x$  over the region  $0 \text{ (cm)} \leq x \leq 3 \text{ (cm)}$ . As a reference, let  $V = 0 \text{ V}$  at  $x = 3 \text{ (cm)}$ .

The figure shows  $E_x$ , the  $x$ -component of the electric field, as a function of position along the  $x$ -axis.



Part A

Graph  $V$  versus  $x$  over the region  $0 \text{ cm} \leq x \leq 3 \text{ cm}$ . As a reference, let  $V = 0 \text{ V}$  at  $x = 3 \text{ cm}$ .

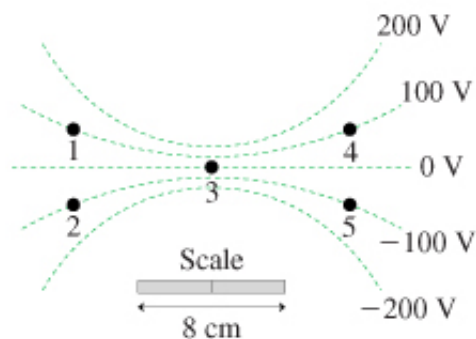
ANSWER:

[View](#)

### Problem 30.46

**Description:** The figure shows a set of equipotential lines and five labeled points. (a) From measurements made on this figure with a ruler, using the scale on the figure, estimate the electric field strength  $E_1$  at the point 1. (b) Estimate the electric field...

The figure shows a set of equipotential lines and five labeled points.



Part A

From measurements made on this figure with a ruler, using the scale on the figure, estimate the electric field strength  $E_1$  at the point 1.

ANSWER:

- $E_1 = 1000 \text{ V/m}$   
  $E_1 = 5000 \text{ V/m}$   
  $E_1 = 20000 \text{ V/m}$

Part B

Estimate the electric field strength  $E_2$  at the point 2.

ANSWER:

- $E_2 = 1000 \text{ V/m}$   
  $E_2 = 5000 \text{ V/m}$   
  $E_2 = 20000 \text{ V/m}$

Part C

Estimate the electric field strength  $E_3$  at the point 3.

ANSWER:

- $E_3 = 1000 \text{ V/m}$   
  $E_3 = 5000 \text{ V/m}$   
  $E_3 = 20000 \text{ V/m}$

Part D

Estimate the electric field strength  $E_4$  at the point 4.

ANSWER:

- $E_4 = 1000 \text{ V/m}$   
  $E_4 = 5000 \text{ V/m}$   
  $E_4 = 20000 \text{ V/m}$

Part E

Estimate the electric field strength  $E_5$  at the point 5.

ANSWER:

- $E_5 = 1000 \text{ V/m}$   
  $E_5 = 5000 \text{ V/m}$   
  $E_5 = 20000 \text{ V/m}$

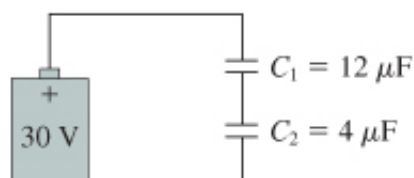
### Problem 30.60

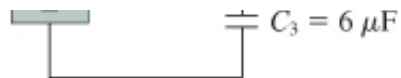
**Description:** (a) What is the charge on each capacitor in the figure? (b) What is the potential difference across each capacitor in the figure...

Part A

What is the charge on each capacitor in the figure?

**Enter your answers numerically separated by commas.**





ANSWER:

$$Q_1, Q_2, Q_3 = \begin{matrix} 60 \\ 60 \\ 60 \end{matrix} \mu\text{C}$$

Part B

What is the potential difference across each capacitor in the figure

Enter your answers numerically separated by commas.

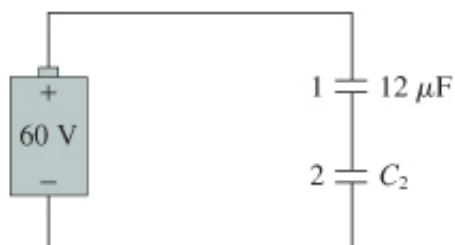
ANSWER:

$$\Delta V_1, \Delta V_2, \Delta V_3 = \begin{matrix} 5 \\ 15 \\ 10 \end{matrix} \text{ V}$$

### Problem 30.68

**Description:** A battery with an emf of 60 V is connected to the two capacitors shown in the figure. Afterward, the charge on capacitor 2 is q. (a) What is the capacitance of capacitor 2?

A battery with an emf of 60 V is connected to the two capacitors shown in the figure. Afterward, the charge on capacitor 2 is 180 μC.



Part A

What is the capacitance of capacitor 2?

Express your answer using two significant figures.

ANSWER:

$$C_2 = \frac{1}{\frac{60}{q} - \frac{1}{12}} \mu\text{F}$$

### Problem 31.40

**Description:** (a) For what electric field strength would the current in a 2.0-mm-diameter nichrome wire be the same as the current in a 1.0-mm-diameter aluminum wire in which the electric field strength is 0.0080 V/m?

Part A

For what electric field strength would the current in a 2.0-~~mm~~-diameter nichrome wire be the same as the current in a 1.0-~~mm~~-diameter aluminum wire in which the electric field strength is 0.0080 V/m?

Express your answer using two significant figures.

ANSWER:

$$E = \begin{array}{c} 0.10 \\ 0.10 \end{array} \text{ V/m}$$

### Problem 31.44

**Description:** In a classical model of the hydrogen atom, the electron moves around the proton in a circular orbit of radius 0.053 nm. (a) What is the electron's orbital frequency? (b) What is the effective current of the electron?

In a classical model of the hydrogen atom, the electron moves around the proton in a circular orbit of radius 0.053 nm.

Part A

What is the electron's orbital frequency?

ANSWER:

$$6.56 \times 10^{15} \text{ Hz}$$

6.56

Part B

What is the effective current of the electron?

ANSWER:

1.05

mA

1.05

### Problem 31.46

**Description:** The biochemistry that takes place inside cells depends on various elements, such as sodium, potassium, and calcium, that are dissolved in water as ions. These ions enter cells through narrow pores in the cell membrane known as ion channels. Each ion...

The biochemistry that takes place inside cells depends on various elements, such as sodium, potassium, and calcium, that are dissolved in water as ions. These ions enter cells through narrow pores in the cell membrane known as *ion channels*. Each ion channel, which is formed from a specialized protein molecule, is selective for one type of ion. Measurements with microelectrodes have shown that a 0.30-nm-diameter potassium ion ( $K^+$ ) channel carries a current of 1.8 pA.

Part A

How many potassium ions pass through if the ion channel opens for 1.0 ms?

ANSWER:

11300

ions

$1.13 \times 10^4$

Part B

What is the current density in the ion channel?

ANSWER:

$2.55 \cdot 10^7$

$A/m^2$

$2.55 \times 10^7$

### Problem 31.50

**Description:** You need to design a 1.0 A fuse that "blows" if the current exceeds 1.0 A. The fuse material in your stockroom melts at a current density of  $500 A/(cm)^2$ . (a) What diameter wire of this material will do the job?

You need to design a 1.0 A fuse that "blows" if the current exceeds 1.0 A. The fuse material in your stockroom melts at a current density of  $500 A/cm^2$ .

Part A



What diameter wire of this material will do the job?

ANSWER:

0.505

mm

**0.505**

### Problem 31.52

**Description:** A hollow metal sphere has inner radius  $a$ , outer radius  $b$ , and conductivity  $\sigma$ . The current  $I$  is radially outward from the inner surface to the outer surface. (a) Find an expression for the electric field strength inside the metal as a function of...

A hollow metal sphere has inner radius  $a$ , outer radius  $b$ , and conductivity  $\sigma$ . The current  $I$  is *radially* outward from the inner surface to the outer surface.

Part A

Find an expression for the electric field strength inside the metal as a function of the radius  $r$  from the center.

ANSWER:

$E(r) = \frac{I}{2\pi\sigma r^2}$

$E(r) = \frac{I}{4\pi\sigma r^2}$

$E(r) = \frac{I}{4\sigma r^2}$

$E(r) = \frac{4\pi\sigma r^2}{I}$

Part B

Evaluate the electric field strength at the inner surface of a copper sphere if  $a = 0.800$  cm,  $b = 3.70$  cm, and  $I = 21.0$  A.

ANSWER:

$$\frac{I0}{24 \cdot 10^7 \pi a 0^2} \quad N/C$$

**4.35×10<sup>-4</sup>**

Part C

Evaluate the electric field strength at the outer surface of a copper sphere if  $a = 0.800 \text{ cm}$ ,  $b = 3.70 \text{ cm}$ , and  $I = 21.0 \text{ A}$ .

ANSWER:

$$\frac{I0}{24 \cdot 10^7 \pi b0^2} \text{ N/C}$$

$$2.03 \times 10^{-5}$$

### Score Summary:

Your score on this assignment is 8.9%.

You received 13.33 out of a possible total of 150 points.