AP Physics 1 – summer packet

Join the AP Physics 1 class (course code m7eywtni) on google classroom.

Over the summer you are responsible for reading and understanding chapters one through three in the 5 steps to a 5 book.

You are also responsible for understanding the course content and makeup of the AP Physics 1 Exam

You must turn in the following on Thursday, September 3rd:

Signed Course Information Sheet
Both Homework assignments*
Completed Metric Measurement Lab*
Completed Vector Lab*

*These will be your first four grades for the first marking period.

You will have a safety quiz on the first day of class – this will count as a lab grade.

You will have an quiz (2 question, 20 minutes) on the first day of class – this will be your first quiz grade.

You will have a test on the summer work (unit I) on the second day of class – this will be your first test grade.

We will start unit II on the second day of class after the test.

All the assignments and additional notes are posted on the AP Physics I google classroom page in the folders labeled summer work and summer answers. YOU ARE EXPECTED TO BE PROFICIENT IN THIS MATERIAL BY THE FIRST DAY OF SCHOOL.

Questions: jgiannattasio@clarkschools.org

Enjoy the summer!!!!
Preliminary Information
2021 EXAM DATE - WEDNESDAY, MAY 5th - afternoon session
AP Physics 1

Classroom Rules

Please be prepared for class each day. This includes your notebook, a pen/pencil and a scientific calculator. You may leave you text at home as a reference unless I specifically ask you to bring it to class. Please be in your seat and ready to begin when the bell rings (not running through the door just as the bell rings). CHEATING IS ABSOLUTELY UNACCEPTABLE and will result in a zero for the assignment and referral to the school administration. I am available for extra help every morning between 7:00 and 7:50 am in my classroom. All missed work is to be made up commensurate with the number of days absent. Late work is not accepted unless it is due to an absence.

Grading Procedure

The final marking period average is determined as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>TESTS</td>
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<tr>
<td>LABS</td>
<td>30%</td>
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<tr>
<td>HOMEWORK</td>
<td>15%</td>
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<tr>
<td>QUIZZES</td>
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Advanced Placement Examination

This course is designed to follow the specific Advanced Placement National Curriculum for Physics 1. Upon completion of this course, students should be able to successfully take the A.P. Physics 1 examination in May. Recognize that this is a college course; accordingly, a large percentage of your grade is based on tests and quizzes. **In accordance with the AP Exam – there are no retakes or any allowances for extra time.**

I have **read and understand** the attached classroom rules and grading policy. I have also reviewed the General Lab Safety Rules and Procedures and understand that no student will be permitted to do laboratory work unless all the safety regulations are met.

Name of Student

Signature of parent/guardian ____________________ Signature of student ____________________
AP Physics Tests

Multiple Choice (8 questions)

- calculator, equation sheet, constant sheet
- You have 30 minutes to complete the multiple choice section.

Free Response (2 questions – NWNCNK)

- calculator, equation sheet, constant sheet
- You have 30 minutes to complete the free-response section.

During all tests and quizzes, I will enter my vegetative proctor state and only answer procedural questions.
General Lab Safety Rules and Procedures

Fire Safety:
- Know where the fire extinguisher is located.
- Know where the exit doors are, and how you would get out of the room should a fire block one of the regular exits.
- Extinguish small fires in a container by covering and cutting off the oxygen with a solid ceramic matte.
- If anyone's hair or clothing catches on fire, immediately try to smother the flames with a wool fire blanket, or cotton clothing. **Do not ever try to smother flames with nylon clothing: it could melt onto the skin. If the fire cannot be immediately smothered, force the person to the ground and roll them over and over, to smother the flames.**
- If the fire is small enough you can try to extinguish it with a fire extinguisher. Make certain that you use an extinguisher designed for a class ABC fire.
- Class D fires involve burning metals such as magnesium. They must be smothered with sand, not a fire extinguisher.

Direct the extinguisher at the base of the flames, and sweep it back and forth across the front of the flames, at their bottom. **Note:** a fire extinguisher has only a few seconds of use.

If the fire is too large to extinguish immediately, evacuate the building, and sound the fire alarm.

Cleanliness:
- Don’t eat or drink in the lab when you are doing an experiment.
- Some of the substances you use are highly poisonous, and/or corrosive so don’t intentionally touch them.
- Make sure to clean up all spilled substances promptly. Almost all the chemicals you use are water soluble, so most can be cleaned up with lots of water and paper towel. You must wear rubber gloves while cleaning up anything corrosive. Organic substances may be insoluble in water, so consult your instructor for the proper cleanup procedure.
- Wash your hands with soap and water, including under your nails, before you leave the lab. Wash them again before you eat.
- Never bring chemicals to your desk. Keep them isolated to the lab counter area of the room.

Wear Eye Protection:
- Most of the substances used in labs are very irritating to your eyes. Some of them can cause blindness. **ALWAYS** wear your goggles when working with materials that may fall, splash, or fly into your eyes, even if it seems the substances are harmless.
- You **do not know for sure** what is in anything. It may have been contaminated, either accidentally or intentionally.
- If you do accidentally get any substance in your eyes, wash them with cool running water for at least 15 minutes (time this). It is virtually impossible to wash out your own eyes if you get a chemical in them. You will instinctively close them, so immediately call for help. If anyone in the lab gets a chemical in their eyes, assist them to the eyewash station, and hold their eyes open while you direct a very gentle stream of body temperature water at their opened eyes. **Get the person's eyes washed with water, and lots of it immediately.** Always get medical attention immediately.
Burns:
- Glass and metal look no different when hot than cold. Be cautious! Always touch any item that has been heated very gently, lightly, and with a damp finger. It takes hot glass a long time—up to 10 minutes or more—to cool to room temperature.
- If you burn yourself, immediately run the burned area under cold water. Inform your teacher. Get medical attention for any burn that raises a blister, or breaks the skin.
- Tie back your hair if it is mid-neck length, or longer.
- Never leave the burner unattended.
- Keep flames away from combustible material. Do not use organic chemicals in the presence of open flames.
- When heating materials in a test tube, always point the tube away from everyone, including yourself.
- Never look into the mouth of a test tube that is being heated.

Using Glassware:
- Broken glassware, must be immediately cleaned up by you and disposed of in a broken glass container. Use a broom and dustpan, not your fingers!
- Never use glassware that is already chipped or cracked. Give it to your lab instructor or dispose of it as directed in a broken glass disposal container.
- If you cut yourself, immediately inform your lab instructor.

General Guidelines:
- Always read through every lab procedure fully, especially including the safety precautions, before you enter the laboratory.
- Always wear closed toe shoes (not sandals) in a laboratory.
- Take only the amount of chemical you need. Never return the excess. It is better to throw out a little bit too much, than to accidentally contaminate the whole container by putting it into the wrong bottle!
- The balances are very delicate (and expensive) instruments. Treat them carefully. If you use proper massing techniques there is no excuse for spilling on them. But if you do accidentally do so, CLEAN IT UP IMMEDIATELY!
- Be careful with hot substances. Almost all the accidents that happen in the lab are burns caused by careless handling of hot objects.
- Never taste anything in the lab. If you need to smell any chemical, waft a few vapors of it gently towards your nostrils with your hand. Never smell anything unless your lab instructor has specifically told you to do so.
- Never work alone while doing chemistry experiments.
- Never work in the lab without the instructor present.
- Have fun, but don't fool around in the lab. Science should be fun, not dangerous!
Flinn Scientific’s Student Safety Contract

PURPOSE

Science is a hands-on laboratory class. You will be doing many laboratory activities which require the use of hazardous chemicals. Safety in the science classroom is the #1 priority for students, teachers, and parents. To ensure a safe science classroom, a list of rules has been developed and provided to you in this student safety contract. These rules must be followed at all times. Two copies of the contract are provided. One copy must be signed by both you and a parent or guardian before you can participate in the laboratory. The second copy is to be kept in your science notebook as a constant reminder of the safety rules.

GENERAL RULES

1. Conduct yourself in a responsible manner at all times in the laboratory.
2. Follow all written and verbal instructions carefully. If you do not understand a direction or part of a procedure, ask the instructor before proceeding.
3. Never work alone. No student may work in the laboratory without an instructor present.
4. When first entering a science room, do not touch any equipment, chemicals, or other materials in the laboratory area until you are instructed to do so.
5. Do not eat food, drink beverages, or chew gum in the laboratory. Do not use laboratory glassware as containers for food or beverages.
6. Perform only those experiments authorized by the instructor. Never do anything in the laboratory that is not called for in the laboratory procedures or by your instructor. Carefully follow all instructions, both written and oral. Unauthorized experiments are prohibited.
7. Be prepared for your work in the laboratory. Read all procedures thoroughly before entering the laboratory.
8. Never fool around in the laboratory. Horseplay, practical jokes, and pranks are dangerous and prohibited.
9. Observe good housekeeping practices. Work areas should be kept clean and tidy at all times. Bring only your laboratory instructions, worksheets, and/or reports to the work area. Other materials (books, purses, backpacks, etc.) should be stored in the classroom area.
10. Keep aisles clear. Push your chair under the desk when not in use.
11. Know the locations and operating procedures of all safety equipment including the first aid kit, eyewash station, safety shower, fire extinguisher, and fire blanket. Know where the fire alarm and the exits are located.
12. Always work in a well-ventilated area. Use the fume hood when working with volatile substances or poisonous vapors. Never place your head into the fume hood.
13. Be alert and proceed with caution at all times in the laboratory. Notify the instructor immediately of any unsafe conditions you observe.
14. Dispose of all chemical waste properly. Never mix chemicals in sink drains. Sinks are to be used only for water and those solutions designated by the instructor. Solid chemicals, metals, matches, filter paper, and other insoluble materials are to be disposed of in proper waste containers, not in the sink. Check the label of all waste containers twice before adding your chemical waste to the container.
15. Labels and equipment instructions must be read carefully before use. Set up and use the prescribed apparatus as directed in the laboratory instructions or by your instructor.
16. Keep hands away from face, eyes, mouth and body while using chemicals or preserved specimens. Wash your hands with soap and water after performing all experiments. Clean all work surfaces and apparatus at the end of the experiment. Return all equipment clean and in working order to the proper storage area.
17. Experiments must be personally monitored at all times. You will be assigned a laboratory station at which to work. Do not wander around the room, distract other students, or interfere with the laboratory experiments of others.
18. Students are never permitted in the science storage rooms or preparation areas unless given specific permission by their instructor.
19. Know what to do if there is a fire drill during a laboratory period; containers must be closed, gas valves turned off, fume hoods turned off, and any electrical equipment turned off.
20. Handle all living organisms used in a laboratory activity in a humane manner. Preserved biological materials are to be treated with respect and disposed of properly.
21. When using knives and other sharp instruments, always carry with tips pointed down and away. Always cut away from your body. Never try to catch falling sharp instruments. Grasp sharp instruments only by the handles.
22. If you have a medical condition (e.g., allergies, pregnancy, etc.), check with your physician prior to working in lab.

CLOTHING

23. Any time chemicals, heat, or glassware are used, students will wear laboratory goggles. There will be no exceptions to this rule.
24. Contact lenses should not be worn in the laboratory unless you have permission from your instructor.
25. Dress properly during a laboratory activity. Long hair, dangling jewelry, and loose or baggy clothing are a hazard in the laboratory. Long hair must be tied back and dangling jewelry and loose or baggy clothing must be secured. Shoes must completely cover the foot. No sandals allowed.
26. Lab aprons have been provided for your use and should be worn during laboratory activities.

ACCIDENTS AND INJURIES

27. Report any accident (spill, breakage, etc.) or injury (cut, burn, etc.) to the instructor immediately, no matter how trivial it may appear.
28. If you or your lab partner are hurt, immediately call out "Code one, Code one" to get the instructor's attention.
29. If a chemical splashes in your eye(s) or on your skin, immediately flush with running water from the eyewash station or safety shower for at least 20 minutes. Notify the instructor immediately.
30. When mercury thermometers are broken, mercury must not be touched. Notify the instructor immediately.

HANDLING CHEMICALS

31. All chemicals in the laboratory are to be considered dangerous. Do not touch, taste, or smell any chemicals unless specifically instructed to do so. The proper technique for smelling chemical fumes will be demonstrated to you.
32. Check the label on chemical bottles twice before removing any of the contents. Take only as much chemical as you need.
33. Never return unused chemicals to their original containers.
Flinn Scientific’s Student Safety Contract

34. Never use mouth suction to fill a pipet. Use a rubber bulb or pipet pump.
35. When transferring reagents from one container to another, hold the containers away from your body.
36. Acids must be handled with extreme care. You will be shown the proper method for diluting strong acids. Always add acid to water, swirl or stir the solution and be careful of the heat produced, particularly with sulfuric acid.
37. Handle flammable hazardous liquids over a pan to contain spills. Never dispense flammable liquids anywhere near an open flame or source of heat.
38. Never remove chemicals or other materials from the laboratory area.
39. Take great care when transporting acids and other chemicals from one part of the laboratory to another. Hold them securely and walk carefully.

HANDLING GLASSWARE AND EQUIPMENT
40. Carry glass tubing, especially long pieces, in a vertical position to minimize the likelihood of breakage and injury.
41. Never handle broken glass with bare hands. Use a brush and duspan to clean up broken glass. Place broken or waste glassware in the designated glass disposal container.
42. Inserting and removing glass tubing from rubber stoppers can be dangerous. Always lubricate glassware (tubing, thistle tubes, thermometers, etc.) before attempting to insert it in a stopper. Always protect your hands with towels or cotton gloves when inserting glass tubing into or removing it from a rubber stopper. If a piece of glassware becomes “frozen” in a stopper, take it to your instructor for removal.
43. Fill wash bottles only with distilled water and use only as intended, e.g., rinsing glassware and equipment, or adding water to a container.
44. When removing an electrical plug from its socket, grasp the plug, not the electrical cord. Hands must be completely dry before touching an electrical switch, plug, or outlet.
45. Examine glassware before each use. Never use chipped or cracked glassware. Never use dirty glassware.
46. Report damaged electrical equipment immediately. Look for things such as frayed cords, exposed wires, and loose connections. Do not use damaged electrical equipment.
47. If you do not understand how to use a piece of equipment, ask the instructor for help.
48. Do not immerse hot glassware in cold water; it may shatter.

HEATING SUBSTANCES
49. Exercise extreme caution when using a gas burner. Take care that hair, clothing, and hands are a safe distance from the flame at all times. Do not put any substance into the flame unless specifically instructed to do so. Never reach over an exposed flame. Light gas (or alcohol) burners only as instructed by the teacher.
50. Never leave a lit burner unattended. Never leave anything that is being heated or is visibly reacting unattended. Always turn the burner or hot plate off when not in use.
51. You will be instructed in the proper method of heating and boiling liquids in test tubes. Do not point the open end of a test tube being heated at yourself or anyone else.
52. Heated metals and glass remain very hot for a long time. They should be set aside to cool and picked up with caution. Use tongs or heat-resistant gloves if necessary.
53. Never look into a container that is being heated.
54. Do not place hot apparatus directly on the laboratory desk. Always use an insulating pad. Allow plenty of time for hot apparatus to cool before touching it.
55. When bending glass, allow time for the glass to cool before further handling. Hot and cold glass have the same visual appearance. Determine if an object is hot by bringing the back of your hand close to it prior to grasping it.

QUESTIONS
56. Do you wear contact lenses?
   □ YES □ NO
57. Are you color blind?
   □ YES □ NO
58. Do you have allergies?
   □ YES □ NO
   If so, list specific allergies

AGREEMENT

I, __________________________, (student’s name) have read and agree to follow all of the safety rules set forth in this contract. I realize that I must obey these rules to ensure my own safety and that of my fellow students and instructors. I will cooperate to the fullest extent with my instructor and fellow students to maintain a safe lab environment. I will also closely follow the oral and written instructions provided by the instructor. I am aware that any violation of this safety contract that results in unsafe conduct in the laboratory or misbehavior on my part, may result in being removed from the laboratory, detention, receiving a failing grade, and/or dismissal from the course.

Student Signature __________________________
Date __________________________

Dear Parent or Guardian:

We feel that you should be informed regarding the school’s effort to create and maintain a safe science classroom/laboratory environment.

With the cooperation of the instructors, parents, and students, a safety instruction program can eliminate, prevent, and correct possible hazards.

You should be aware of the safety instructions your son/daughter will receive before engaging in any laboratory work...Please read the list of safety rules above. No student will be permitted to perform laboratory activities unless this contract is signed by both the student and parent/guardian and is on file with the teacher.

Your signature on this contract indicates that you have read this Student Safety Contract, are aware of the measures taken to ensure the safety of your son/daughter in the science laboratory, and will instruct your son/daughter to uphold his/her agreement to follow these rules and procedures in the laboratory.

Parent/Guardian Signature __________________________
Date __________________________
### Advanced Placement Physics 1 Table of Information

#### Constants and Conversion Factors

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<tr>
<td>Neutron mass, $m_n$</td>
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<tr>
<td>Electron mass, $m_e$</td>
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<tr>
<td>Speed of light, $c$</td>
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<td>Electron charge magnitude, $e$</td>
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<tr>
<td>Coulomb’s law constant, $k$</td>
<td>$1/4\pi\varepsilon_0 = 9.0 \times 10^9$ N.m^2/C^2</td>
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<tr>
<td>Universal gravitational constant, $G$</td>
<td>$6.67 \times 10^{-11}$ m^3/kg.s^2</td>
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<tr>
<td>Acceleration due to gravity at Earth’s surface, $g$</td>
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#### UNIT SYMBOLS

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#### PREFIXES

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#### VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES

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<td>tan θ</td>
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<td>3/4</td>
<td>1</td>
<td>$\sqrt{3}$</td>
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The following conventions are used in this exam:

I. The frame of reference of any problem is assumed to be inertial unless otherwise stated.

II. Assume air resistance is negligible unless otherwise stated.

III. In all situations, positive work is defined as work done on a system.

IV. The direction of current is conventional current: the direction in which positive charge would drift.

V. Assume all batteries and meters are ideal unless otherwise stated.
# Advanced Placement Physics 1 Equations

## Mechanics

- \( v_x = v_{x0} + a_x t \)
- \( x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2 \)
- \( v_x^2 = v_{x0}^2 + 2a_x (x - x_0) \)
- \( \ddot{a} = \frac{\sum F_i \cdot \hat{n}}{m} = \frac{\vec{F}_{\text{net}}}{m} \)
- \( |F_f| \leq \mu |\vec{F}_n| \)
- \( a_c = \frac{v^2}{r} \)
- \( \ddot{p} = m \ddot{v} \)
- \( K = \frac{1}{2} \text{mv}^2 \)
- \( \Delta E = W = F_i d = F d \cos \theta \)
- \( p = \frac{\Delta E}{\Delta t} \)
- \( \theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2 \)
- \( \omega = \omega_0 + \alpha t \)
- \( x = A \cos(2\pi ft) \)
- \( \vec{a} = \frac{\sum F_i}{I} = \frac{\vec{F}_{\text{net}}}{I} \)
- \( \Delta U_s = mg \Delta y \)
- \( \tau = r \omega F = rF \sin \theta \)
- \( L = I \omega \)
- \( \Delta L = \tau \Delta t \)
- \( K = \frac{1}{2} I \omega^2 \)
- \( |\vec{F}_e| = k |\vec{E}| \)
- \( \vec{F}_g = \frac{G m_1 m_2}{r^2} \)
- \( \rho = \frac{m}{V} \)
- \( U_G = -\frac{G m_1 m_2}{r} \)

## Electricity

- \( |\vec{F}_E| = k \frac{q_1 q_2}{r^2} \)
- \( I = \frac{\Delta q}{\Delta t} \)
- \( P = \frac{I \Delta V}{R} \)
- \( \frac{1}{R_p} = \sum \frac{1}{R_i} \)

## Waves

- \( \lambda = \frac{v}{f} \)

## Geometry and Trigonometry

### Right triangle

- \( c^2 = a^2 + b^2 \)
- \( \sin \theta = \frac{a}{c} \)
- \( \cos \theta = \frac{b}{c} \)
- \( \tan \theta = \frac{a}{b} \)

### Rectangle

- \( A = bh \)
- \( C = \text{circumference} \)
- \( V = \text{volume} \)

### Triangle

- \( A = \frac{1}{2} bh \)
- \( b = \text{base} \)
- \( h = \text{height} \)
- \( \ell = \text{length} \)

### Circle

- \( A = \pi r^2 \)
- \( C = 2\pi r \)
- \( w = \text{width} \)
- \( r = \text{radius} \)

### Rectangular solid

- \( V = \ell wh \)

### Cylinder

- \( V = \pi r^2 \ell \)
- \( S = 2\pi \ell r + 2\pi r^2 \)

### Sphere

- \( V = \frac{4}{3} \pi r^3 \)
- \( S = 4\pi r^2 \)
TRIG EQUATIONS

\[ \sin \theta = \frac{\text{opp}}{\text{hyp}} \]
\[ \cos \theta = \frac{\text{adj}}{\text{hyp}} \]
\[ \tan \theta = \frac{\text{opp}}{\text{adj}} \]

KINEMATICS EQUATIONS

\[ 2 \Delta d = (v_f + v_i)t \]
\[ \Delta d = v_i t + \frac{1}{2}at^2 \]
\[ v_f = v_i + at \]
\[ v_f^2 = v_i^2 + 2a \Delta d \]

projectiles:
\[ \Delta d_x = v_xt \]
\[ \Delta d_y = v_y t + \frac{1}{2}gt^2 \]
\[ v_x = v_i (\cos \theta) \]
\[ v_y = v_i (\sin \theta) \]

DYNAMICS EQUATIONS

\[ \Sigma F = ma \]
\[ f = \mu F_N \]
\[ F_g = mg \]

inclines:
\[ F_{\parallel} = F_g (\sin \theta) \]
\[ F_N = F_g (\cos \theta) \]

WORK / NRG EQUATIONS

\[ W = F \cdot \Delta d \]
\[ GPE = mgh \]
\[ KE = \frac{1}{2}mv^2 \]
\[ EPE = \frac{1}{2}kx^2 \quad F = kx \]
\[ PE_i + KE_i + W_c = PE_f + KE_f + W_n \]
\[ P = \frac{W}{t} \]

IMPULSE / MOMENTUM EQUATIONS

\[ I = F \cdot t \]
\[ p = m \cdot v \]
\[ \Delta p = F \cdot t \]
\[ m \cdot \Delta v = F \cdot t \]
\[ m_1 v_1 + m_2 v_2 + \ldots = m_1 V_1 + m_2 V_2 + \ldots \]

CIRCULAR MOTION EQUATIONS

\[ f = \frac{1}{T} \]
\[ v = \frac{2 \pi r}{T} \]
\[ \Sigma F_c = m \frac{v^2}{r} \]

gravitation:
\[ F_g = G \frac{m_1 m_2}{r^2} \]
\[ \frac{R_1^3}{T_1^2} = \frac{R_2^3}{T_2^2} \]
\[ \frac{R^3}{T^2} = \frac{Gm}{4\pi^2} \]
TORQUE EQUATION

\[ \tau = F \cdot \ell \]

BUOYANCY / FLUIDS EQUATIONS

\[ B = \rho V g \]
\[ P = \frac{F}{A} \]
\[ P = P_0 + \rho gh \]
\[ v_1 A_1 = v_2 A_2 \]
\[ P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2 \]
\[ \rho = \frac{m}{V} \]

THERMAL PHYSICS EQUATIONS

\[ KE = \frac{3}{2} k T \]
\[ \Delta L = L \alpha \Delta T \]
\[ \Delta V = V \beta \Delta T \]
\[ Q = mc \Delta T \]
\[ Q = mh_r \]
\[ Q = mh_v \]
\[ Q_{\text{lost}} = Q_{\text{gained}} \]

WAVE / OSCILLATORY EQUATIONS

\[ v = \lambda f \]
\[ v = \frac{d}{t} \]
\[ T_s = 2\pi \sqrt{\frac{m}{k}} \]
\[ T_p = 2\pi \sqrt{\frac{\ell}{g}} \]

THERMODYNAMICS EQUATIONS

\[ \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \]
\[ PV = nRT \]
\[ \Delta U = Q + W \]
\[ W = -P_{\text{avg}} \Delta V \]
\[ \Delta V = V_f - V_i \]
\[ Q = nC_p \Delta T \]
\[ Q = nC_v \Delta T \]
\[ \Delta U = \frac{3}{2} nR \Delta T \]
\[ \Delta T = T_f - T_i \]

heat engines:

\[ Q_H = W + Q_L \]
\[ \text{Eff} = \frac{W}{Q_H} \]
\[ \text{Eff}_{\text{max}} = 1 - \frac{Q_L}{Q_H} \]

SOUND EQUATIONS

\[ \beta = 10 \log \frac{I}{I_o} \]
\[ I = \frac{P}{A} \]
\[ I = \frac{P}{4\pi r^2} \]

\[ f = f \left( \frac{V \pm v_o}{V \pm v_i} \right) \]

standing waves:

strings

\[ \lambda = \frac{2L}{n} \quad n = 1,2,3,4,\ldots \]

\[ v = \sqrt{\frac{F_r}{\mu}} \quad \mu = \frac{m}{\ell} \]

air columns

open \quad \lambda = \frac{2L}{n} \quad n = 1,2,3,4,\ldots \]

closed \quad \lambda = \frac{4L}{n} \quad n = 1,3,5,7,\ldots \]
LIGHT AND OPTICS EQUATIONS

\[ n = \frac{c}{v} \]

\[ n_1 \sin \theta_1 = n_2 \sin \theta_2 \]

\[ \theta_e = \sin^{-1}\left(\frac{n_2}{n_1}\right) \]

\[ d \sin \theta = m\lambda \quad m = \text{order maximum} \]

\[ \tan \theta = \frac{x}{L} \]

\[ \omega \sin \theta = m\lambda \quad m = \text{order minimum} \]

\[ \lambda_{\text{medium}} = \left(\frac{\lambda_{\text{air}}}{n_{\text{medium}}}\right) \]

\[ 2t = \left(\frac{\#}{2}\right)\lambda_{\text{medium}} \]

\[ \frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \quad M = -\frac{d_i}{d_o} \quad M(h_o) = h_i \]

ELECTROSTATICS EQUATIONS

\[ F_e = k \frac{Q_1 Q_2}{d^2} \]

\[ E = k \frac{Q}{d^2} \]

\[ F = Eq \]

\[ V = k \frac{Q}{d} \quad W = Vq \quad \frac{1}{2}mv^2 = Vq \]

\[ V = E \cdot d^* \]

\[ C = \frac{Q}{V} \quad C = \kappa \varepsilon_o \frac{A}{d} \]

\[ \text{PE}_e = \frac{1}{2}QV \]

\[ C_p = C_1 + C_2 + C_3 + \ldots \]

\[ \frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \]

ELECTROMAGNETISM EQUATIONS

\[ B = \mu_o \frac{1}{2\pi r} \]

\[ F = I \ell B \]

\[ F = qvB \]

\[ r = \frac{mv}{qB} \]

\[ E = vB^* \]

\[ \Phi = BA \]

\[ \varepsilon = \frac{\Delta \Phi}{t} \]

\[ \varepsilon = NB\ell v \]

CURRENT ELECTRICITY EQUATIONS

\[ V = IR \]

\[ P = IV \quad P = I^2 R \quad P = \frac{V^2}{R} \]

\[ I = \frac{Q}{t} \]

\[ R = \frac{\rho \ell}{A} \]

\[ R_s = R_1 + R_2 + R_3 + \ldots \]

\[ \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \]
ROTARY MOTION
\[ \tau = F \cdot \ell \]
\[ a = \alpha r \quad v = \omega r \quad \Delta d = \Delta \theta r \]
\[ 2\Delta \theta = (\omega_f + \omega_i)t \]
\[ \Delta \theta = \omega_it + \frac{1}{2}a\alpha t^2 \]
\[ \omega_f = \omega_i + \alpha t \]
\[ \omega_f^2 = \omega_i^2 + 2a\Delta \theta \]
\[ \Sigma \tau = I\alpha \quad KE = \frac{1}{2}I\omega^2 \]
\[ L = I \omega \]

SOUND EQUATIONS
\[ \beta = 10\log \frac{I}{I_0} \]
\[ I = \frac{P}{A} \]
\[ I = \frac{P}{4\pi r^2} \]
\[ f' = f \left( \frac{v \pm v_o}{v \pm v_s} \right) \]

standing waves:

strings
\[ \lambda = \frac{2L}{n} \quad n = 1, 2, 3, 4, \ldots \]
\[ v = \sqrt{\frac{F_T}{\mu}} \quad \mu = \frac{m}{\ell} \]

air columns
open \[ \lambda = \frac{2L}{n} \quad n = 1, 2, 3, 4, \ldots \]
closed \[ \lambda = \frac{4L}{n} \quad n = 1, 3, 5, 7, \ldots \]

MODERN PHYSICS EQUATIONS
\[ E = hf \]
\[ E = \left( \frac{1240}{\lambda} \right) \]
\[ KE_{\text{max}} = hf - W_o \]
\[ W_o = hf_o \quad W_o = \left( \frac{1240}{\lambda_o} \right) \]
\[ KE_{\text{max}} = -qV_o \]
\[ p = \frac{h}{\lambda} \]
\[ \lambda_{\text{deBroglie}} = \frac{h}{mv} \]
\[ E = mc^2 \]
The Lab “Write Up”

Categories

Each lab “write up” should contain the following categories:

Objective
Apparatus/Materials
Procedure
Data
Conclusion

Lab format and expectations for each category

Objective
The objective will be given by the instructor and in most cases will be in the form of a question.

Apparatus/Materials
This section should include everything that is used when performing the lab.

Procedure
This section should contain an explicit explanation of exactly what you did as you performed the experiment. This could be in paragraph form, outline form, etc.

Data
This is a very important part of your experiment and would naturally contain all qualitative and quantitative observations and your results. In this section you should indicate exactly what happened. This section should include all drawings, charts, graphs, etc.

Conclusion
This is the most important section of your lab “write up”. It must be ORIGINAL.
This section should contain a number of statements, or paragraphs, or pages that will specifically and explicitly answer in detail the question asked in the objective.
The answers to the objective questions without an explanation of your answers are not fully acceptable.
You should definitely explain how the performance of the particular lab enabled you to develop your conclusion. This is critical.
Research materials may be used as an aid in your interpretation. Answers to the objective question that is based only on research data will not be acceptable.
An Optional Lab Category

Background Information
This section could be a statement to several pages. This information can be used to aid you in proposing a conclusion; however, it cannot be the conclusion. In most cases, this information is obtained by doing research. It should be done before you finalize your conclusion (in many cases, before you begin to write your conclusion). It is important to remember that the information in this section will probably help you to better understand what you have done.
Note: this section should follow the objective section of your “write up”

Summary and Quick Review

A good lab report conclusion should contain the following three things.

- The answer to the objective question along with full support from the data.
- An inference, an explanation of why the system behaved as it did based on scientific principles.
- A prediction, a guess as to how the system will behave outside the parameters of the collected lab data.
Notes
PHYSICS SKILL

Graphing Techniques

Frequently an investigation will involve finding out how changing one quantity affects the value of another. The quantity that is deliberately varied is called the independent variable. The quantity that changes due to the variation in the independent variable is called dependent variable.

More often than not the relationship between the independent and dependant variable is not obvious from simply looking at the written data. However, if one quantity is plotted against the other, the resulting graph gives evidence of what sort of relationship, if any, exists between the variables. When plotting a graph, take the following steps.

1. Identify the independent and dependent variable.

2. Choose your scale carefully. Make your graph as large as possible by spreading out the data on each axis. Let each space stand for a convenient amount. Choosing three spaces equal to 10 is not convenient because each space is an awkward fraction. Choosing five spaces equal to 10 would be better. To avoid a cluttered appearance, you do not need to number every space.

3. Plot the independent variable on the horizontal (x) axis [abscissa] and the dependent variable on the vertical (y) axis [ordinate]. Plot each point as a dark dot with a small circle around it.

4. Label each axis with the name of the variable and the unit. Using a ruler, darken the lines representing the axis.

5. Title your graph. The title should clearly state the purpose of the graph and include the independent and dependent variables.

6. If the data points appear to lie roughly in a straight line, draw the best straight line you can with a ruler and sharp pencil. Have the line go through as many points as possible with approximately the same number of points above the line as below. Never “connect the dots.” If the points do not form a straight line, draw the best smooth curve possible.

7. All graphs do not go through the origin (0,0). Think about your experiment and decide if the data would logically include a (0,0) point. For example, if a cart is at rest when you start the timer, then your graph of speed versus time would go through the origin. If the cart is already in motion when you start the timer, your graph will not go through the origin.

Below is a graph using good graphing techniques. Go back and check each of the items mentioned above.

<table>
<thead>
<tr>
<th>Force (N)</th>
<th>Elongation (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>2</td>
<td>3.0</td>
</tr>
<tr>
<td>3</td>
<td>4.5</td>
</tr>
<tr>
<td>4</td>
<td>6.0</td>
</tr>
<tr>
<td>5</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Elongation versus Force
Graph the following sets of data – place the first column on the x-axis. Discuss the shape and meaning of each graph and the relationship between the variables.

1. | Pressure (torr) | Volume (mL) |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>800</td>
</tr>
<tr>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>400</td>
<td>200</td>
</tr>
<tr>
<td>600</td>
<td>133</td>
</tr>
<tr>
<td>700</td>
<td>114</td>
</tr>
<tr>
<td>800</td>
<td>100</td>
</tr>
<tr>
<td>1000</td>
<td>80</td>
</tr>
</tbody>
</table>

2. | Time (s) | Distance (m) |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>45</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>125</td>
</tr>
</tbody>
</table>

3. | Time (s) | Speed (m/s) |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>84</td>
</tr>
<tr>
<td>5</td>
<td>105</td>
</tr>
</tbody>
</table>
Graphing and Relationships of Variables

A graph is a diagram that illustrates by means of points and lines a relationship between different variables whose values are plotted on the graph. Graphical analysis also helps us determine the type of mathematical equation that relates the variables being graphed.

Part 1: Graphing procedures

1. The data is most commonly plotted on Cartesian paper in which the lines are set up in a linear fashion. The horizontal line with the value of zero is called the x-axis and the vertical line with the value of zero is called the y-axis. You may be told to plot one variable versus another. If so, the variable given before the "Versus" goes on the y-axis and the variable after versus goes on the x-axis. In general when plotting data, the independent variable (the one the experimenter controls) goes on the x-axis and the dependent variable goes on the y-axis. This is not a hard and fast rule, and may be changed by the instructor during some labs.

2. When plotting data, choose axis scales that are easy to plot and read. If possible, choose scales so that over half of each axis is used to plot data points. (At times, for the graphs to start at zero, this rule may need to be ignored.) Graph A illustrates an example of scales that are too small. Graph B shows the data plotted with more appropriate scales. The scales must be uniform, i.e. every small box is worth the same amount.

3. When the data points are plotted, draw a smooth best-fit-line for the points. It is appropriate to ignore a data point that seems far off. Never play connect the dots!!! - as shown in Graph A. If the best fit is a straight line, always use a ruler to draw the line; if the best fit for the data is a curved line, draw a smooth curve.

4. In cases where several sets of data are taken for each trial, the average value is plotted. If more than one line is plotted, be sure to label the lines or provide a key.

5. Make sure all graphs have the following:
   a) Each axis labeled with quantity plotted.
   b) The unit of the quantity plotted.
   c) The title of the graph on the paper (commonly listed as the y variable versus the x variable).

Graphs A and B were made with the following data obtained by hanging weights on a spring and measuring how far the spring stretched.

<table>
<thead>
<tr>
<th>weight on spring (N)</th>
<th>.25</th>
<th>.50</th>
<th>.75</th>
<th>1.00</th>
<th>1.25</th>
<th>1.50</th>
<th>1.75</th>
<th>2.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>distance spring stretched (cm)</td>
<td>.80</td>
<td>2.41</td>
<td>2.74</td>
<td>3.69</td>
<td>5.20</td>
<td>6.28</td>
<td>6.72</td>
<td>8.85</td>
</tr>
</tbody>
</table>

*Notice how the data is completely labeled. You are expected to write down more than weight and distance when taking data. Indicate what weight and what distance.
Part 2: Processing straight line graphs

A graph in which the data points yield a straight line is called a linear graph. When the intercept is zero, we say that the variable on the y-axis is directly proportional to the variable on the x-axis. That phrase "directly proportional" tells you that if the variables doubles, so does the other. When the intercept is not zero, we say that the change in the variable on the y-axis is directly proportional to the change in the variable on the x-axis. For the graph B, the relationship of the data is that the change in the weight hanging on the spring is directly proportional to the change in the distance the spring is stretched. This means by whatever factor the force is changed, the displacement will change by the same factor. To understand what this means, on graph B, the value for the line at zero stretch is .05 N at and 4.0 cm of stretch the weight is .95 N. Let's double the stretch to 8.0 cm and see the weight is now 1.85 N. We doubled the stretch and the weight did not quite double. Now let's look at the change in the variables. When the stretch is changed from zero to 4.0 cm, the weight changes from .03 N to .94 N or a change or .91 N. When the stretch is doubled to 8.0 cm, the weight changes from .03 N to 1.85 N, for a change of 1.82 N. This shows that when the change in stretch is doubled (from 4.0 cm to 8.0 cm) the change in weight also doubled (from .91 N to 1.82 N).

When a graph is linear, the x and y variables have an algebraic relationship of the form \( y = mx + b \). The \( b \) in the equation is called the intercept and is equal to the value of \( y \) when the line crosses the y-axis. The \( m \) in the equation is called the slope and is equal to change in y divided by change in x (\( \Delta y / \Delta x \)). Any two points on the line should yield the same value, however it is best to pick points that are far apart. It is best if data points are not used, and never use a data point that is not exactly on the line. On graph B, two points have been indicated by arrows. They will be used to calculate the slope. One point has the values \( (x_1 = 1.20 \text{ cm}, y_1 = .30 \text{N}) \) and the other \( (x_2 = 6.40 \text{ cm}, y_2 = 1.50 \text{ N}) \).

To find the slope we use the equation for slope, as shown below.

\[
    m = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{1.50 \text{N} - .30 \text{N}}{6.4 \text{cm} - 1.2 \text{cm}} = \frac{1.20 \text{N}}{5.2 \text{cm}} = .23 \frac{\text{N}}{\text{cm}}
\]

Notice that the units are included when the slope is calculated.

The complete equation for the data is weight = (.23 \( \frac{\text{N}}{\text{cm}} \)) distance + .03 N

In physics, we usually let symbols or letters represent the variables. In this case, the final equation becomes

\[
    W = (.23 \frac{\text{N}}{\text{cm}}) d + .03 \text{ N}
\]

Notice in this equation the slope and the intercept have units, and the variables do not. When any value for the distance stretched is put into the equation with its unit, the similar unit in the slope should cancel out.

Horizontal straight lines

Occasionally data will produce a graph with an appearance similar to the diagram to the right. This graph indicates that as the variable plotted on the x-axis changes, the variable on the y-axis stays the same. There is no relationship between the two variables. When asked to state what this type of graph indicates, one says, "\( y \) is independent of \( x \)."

The line has a slope of zero and the intercept is the same value as every other point on the line. Therefore the algebraic relationship is \( y = b \).
Part 3: Curved graphs

In the work you will be doing, when the data produces a curved graph, the graph will need to be linearized before you can write the equation for the relationship. The shape of the graph will give you a clue on how to linearize it. Here are the three basic shapes you will run into for curved graphs.

A. Top opening parabola

The shape the graph to the right is a top opening parabola. The line on the graph becomes steeper as the line goes to the right. In the work we will do, in the equation $y = kx^2$, the power "n" is either 2 or 3. In other words, the equation relating the two variables will be either $y = kx^2$ or $y = kx^3$.

To straighten out a graph with this shape, all the data graphed on the x-axis (horizontal) must be squared or cubed. The data graphed on the y-axis (vertical) is not changed.

If asked to state the relationship of two variables when $y = kx^2$, one states that "y is proportional to x squared". For example, when an object is dropped, the distance it falls is proportional to the time squared. This means if the time the object falls is doubled, the distance it falls is quadrupled.

B. Hyperbola

The shape of the graph to the right is a hyperbola. The curved line on the graph goes down as the line goes to the right. This type of graph indicates illustrates what is called an inverse relationship. If one quantity increases, the other decreases. In the work we will do, in the equation $y = kx^2$, the power "n" is either -1 or -2. In other words, the equation relating the two variables will be either $y = kx^{-1}$ or $y = kx^{-2}$ or more commonly, $y = \frac{k}{x}$ or $y = \frac{k}{x^2}$.

To straighten out a graph with this shape, all the data graphed on the x-axis must be divided into 1, or it must be squared and that number divided into 1. The data graphed on the y-axis is not changed.

If asked to state the relationship of two variables when $y = \frac{k}{x}$, one states that "y is inversely proportional to x". For example, in an electric circuit, when the resistance is doubled, the amount of current is cut in half.

Therefore the current is inversely proportional to the resistance. The power carried by a sound is inversely proportional to the distance squared from the source of the sound. This means if you double the distance from the sound source, the power carried by the sound is one fourth as much.

C. Side opening parabola

The shape of the graph to the right is a side opening parabola. The curved line on the graph goes up and becomes less steep as the line goes to the right. In the work we will do, in the equation $y^n = kx$, the power "n" is either 2 or 3. In other words, the equation relating the two variables will be either $y^2 = kx$ or $y^3 = kx$.

This means the square or the cube of the data graphed on the y-axis must be plotted to straighten out the graph. The data graphed on the x-axis is not changed. (Notice this is the opposite of what we did on the other graphs.)

If asked to state the relationship of two variables when $y^2 = kx$, one states, "y squared is proportional to x". For example, when the mass hanging on a spring is quadrupled, the time it takes for one trip up and down for the mass is twice as much. Therefore, the time squared for a trip is proportional to the mass on the spring.
Part 4: Straightening curved graphs

For a curved graph, before the exact relationship can be determined and the equation for it written, the graph needs to be straightened out. This is done by modifying the data plotted on x-axis and reploting the points.

The data below was taken during an experiment in which masses were hung on a vertical spring. The mass was pulled down and released. The time for one complete oscillation was recorded. This data will be used to show the process of straightening a curved graph and writing the equation relating the mass on the spring and the time for one oscillation. The data is plotted on the graph to the right.

<table>
<thead>
<tr>
<th>mass hung on spring (kg)</th>
<th>.10</th>
<th>.20</th>
<th>.30</th>
<th>.40</th>
<th>.50</th>
<th>.60</th>
</tr>
</thead>
<tbody>
<tr>
<td>time for one oscillation (s)</td>
<td>.68</td>
<td>.92</td>
<td>1.16</td>
<td>1.29</td>
<td>1.50</td>
<td>1.66</td>
</tr>
</tbody>
</table>

1. Plot the data. (Shown on graph C.)

2. Identify the shape of the curve. This curve is a side opening parabola. That shape tells us that the time squared or cubed is proportional to the mass.

3. The data on the y-axis must be taken to one of the powers that go with the type of curve. To make a test graph, take the square of the times in the original data table. Do not change the data on the x-axis.

<table>
<thead>
<tr>
<th>mass hung on spring (kg)</th>
<th>.10</th>
<th>.20</th>
<th>.30</th>
<th>.40</th>
<th>.50</th>
<th>.60</th>
</tr>
</thead>
<tbody>
<tr>
<td>time² for one oscillation (s²)</td>
<td>.46</td>
<td>.85</td>
<td>1.35</td>
<td>1.66</td>
<td>2.25</td>
<td>2.75</td>
</tr>
</tbody>
</table>

4. Plot the modified data. (Shown on graph D.) Since the points are linear (ignoring the one bad point), a straight line is drawn. We can now definitely say the time squared is proportional to the mass. (For example, if the mass is increased by a factor of 2, the time will increase by a factor of 2.)

5. Take the slope of the line and write the equation for the relationship.

The arrows indicate points used for the slope. Point 1 is x = .20 kg, y = .90 s², point 2 is x = .48 kg, y = 2.2 s².

\[ m = \frac{2.2 s^2 - .90 s^2}{.48 kg - .20 kg} = \frac{1.3 s^2}{28 kg} = 4.6 \frac{s^2}{kg} \]

So the equation for the relationship is \[ t^2 = \frac{4.6 s^2}{kg} \cdot \text{mass} + 0 \], or \[ t^2 = 4.6 \frac{s^2}{kg} \cdot \text{mass} \].

Part 5: Sample problems involving variable relationships

1) Answer the following questions about the following equation: \( d = \frac{1}{2} at^2 \). 
   
   a) State the relationship of distance and acceleration.

   b) If time is kept constant and the acceleration is doubled, by what factor does the distance traveled change?

   c) State the relationship of distance and time.
d) If the acceleration is kept constant and the time is tripled, by what factor does the distance traveled change?

e) State the relationship for acceleration and time.

f) If the distance is kept constant and the time to cover that distance is cut in half, by what factor does the acceleration change?

g) If the acceleration is constant, and the distance is quadrupled, what happens to the time?

Problems:
1) Title the two graphs below, calculate the slopes and write the equation for the line.
2) In the data in the table below, the first column is the independent variable, and the second column is the dependent variable. Graph the following set of data on the grid provided. When done, calculate the slope of the line and write the equation for the line.

<table>
<thead>
<tr>
<th>Potential difference (volts)</th>
<th>Current (amps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>15.0</td>
</tr>
<tr>
<td>0.30</td>
<td>20.0</td>
</tr>
<tr>
<td>0.40</td>
<td>24.2</td>
</tr>
<tr>
<td>0.50</td>
<td>31.0</td>
</tr>
<tr>
<td>0.75</td>
<td>45.0</td>
</tr>
<tr>
<td>1.00</td>
<td>59.8</td>
</tr>
</tbody>
</table>

Equation:____________________

3) Plot the data below on the grid.

What type of relationship is shown?____________________

Modify the data and show the new data table in the area below.

<table>
<thead>
<tr>
<th>volume (in³)</th>
<th>pressure (bars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.0</td>
<td>29.1</td>
</tr>
<tr>
<td>11.0</td>
<td>31.0</td>
</tr>
<tr>
<td>10.0</td>
<td>35.3</td>
</tr>
<tr>
<td>9.0</td>
<td>39.3</td>
</tr>
<tr>
<td>7.5</td>
<td>47.1</td>
</tr>
<tr>
<td>6.0</td>
<td>58.8</td>
</tr>
<tr>
<td>5.0</td>
<td>70.7</td>
</tr>
</tbody>
</table>

Modified data table:

Plot the modified data on the grid on the next page.
Write the complete equation for the modified graph.

4) This is a graph that Lena made for her first two weeks at Burger World.
   a) Which is the dependent variable and which is the independent? How do you know?

b) What is the slope for this graph? What is the slope the value of?

c) What is the mathematical model (equation) which describes the graph?

d) State the relationship of the variables?
5) Dan performed an experiment with a metal sphere. He shot the sphere from a slingshot and measured its maximum height. Six different trials were performed with the sphere being shot at a different angle from the horizontal for each trial.

a) What is the relationship being studied?

b) What is the independent variable in this experiment?

c) What is the dependent variable in this experiment?

d) What other variables must be held constant throughout this experiment?

---

6) Sally did an electricity lab that produced the graph above.

a) What is the shape of this graph? What type of relationship does this graph suggest?

b) What variables should Sally plot to linearize the data?

c) If what Sally did in (b) linearized the graph, what are the units of the line's slope?

d) If what Sally did in (b) produced a graph with shape of the sketch to the right, what variables should she plot to try and linearize the data?
7) a) Below is a careful study of the relationship between wirbles and didacs. The data produced the linearized graph below. Title the graph and determine the equation for the graph below? (Show setup for the slope.)

![Graph showing the relationship between wirble (b) and didacs^2 (n^2).]

b) Sketch the shape of the graph before it was linearized? What is the shape of that graph called? What was its independent variable?

c) State the relationship of the variables?

Answer the questions following each of the equations below.

\[ \text{potential difference} = \text{current} \times \text{resistance}, V = IR \]

8a) What is the relationship between potential difference and current?

b) If the potential difference is doubled, by what factor will the current change?

c) What is the relationship between current and resistance?

d) If the potential difference is unchanged and the resistance is doubled, by what factor will the current change?
kinetic energy = \( \frac{1}{2} \) mass \( \times \) velocity\(^2\), KE = \( \frac{1}{2} \) mv\(^2\)

9a) What is the relationship between kinetic energy and velocity?

b) If the velocity increases by a factor of 4, by what factor will the kinetic energy change?

c) If the velocity changes to one half of the original, by what factor will the kinetic energy change?

d) If the velocity remains the same and the mass is tripled, by what factor will the KE change?

\[ \text{force} = (\text{Coulomb's constant}) \frac{\text{charge one} \times \text{charge two}}{\text{distance apart}^2}, \quad F = k \frac{q_1 q_2}{d^2} \]

10a) What is the relationship between force and distance apart?

b) What is the relationship between force and charge two?

c) If the charges are unchanged and the distance apart is tripled, by what factor will the force change?

d) If the charges are unchanged and the distance apart is 1/4th as much, by what factor will the force change?

\[ \text{period}^2 = 4\pi^2 \frac{\text{length of pendulum}}{\text{gravitational field strength}}, \quad T^2 = (4\pi^2) \frac{L}{g} \]

11a) What is the relationship between the period and the length?

b) If the period is to be tripled, by what factor must the length change?

c) If the length is doubled, by what factor will the period change?

d) If the length is decreased to one sixteenth as much, by what factor will the period change?

e) If the pendulum is taken to a planet where gravitational field strength is 4 times more, by what factor will the period change?
Vectors

1. State whether the following quantities are vectors or scalars.
   a) distance
   b) displacement
   c) 5 miles per hour
   d) 10 meters per second east
   e) 100 foot directly down
   f) 50 kilograms
   g) 2 seconds
   h) 100 degrees Celsius
   i) velocity

2. Why is a car's odometer reading always a scalar quantity?

3. A turtle walks in various random directions covering arbitrary distances. He finally arrives back at his original location. What is the turtle's total displacement from start to finish?

4. A boy walks 10 feet west, 5 feet north, 3 feet east, and 5 feet south. What is his resulting displacement?

5. Discuss how vector quantities are represented on paper.
Significant Digits

The numbers reported in a measurement are limited by the measuring tool.

Significant figures in a measurement include the known digits plus one estimated digit.

**RULE 1.** All non-zero digits in a measured number are significant.

**RULE 2.** Leading zeros in decimal numbers are __________.

**RULE 3.** Zeros ________ nonzero numbers are significant.

**RULE 4.** Trailing zeros in numbers ________ decimals are NOT significant.

Use the above rules to determine the correct number of significant digits in the following.

a) 16.70 cm  
b) 22.09 L  
c) 1.00014 km  
d) 0.01239709 sec

Mathematical Calculations:

A calculated answer cannot be more precise than the measuring tool.

A calculated answer must match the least precise measurement.

Addition and Subtraction:

The answer has the same number of decimal places as the measurement with the ________ decimal places.

For example, if we add the following quantities 44.1 kg + 8.002 kg + 0.93 kg, the sum is 53.032 kg. However the least precise measurement, which is ________, is precise only to the nearest one-tenth. The sum of the answers must accordingly be rounded to the nearest one-tenth. The answer is 53.0 kg to the proper number of significant digits.

Perform the following; report your answer to the correct number of significant digits.

a) \[ 2.645 \text{ s} + 11.34 \text{ s} + 58.325 \text{ s} + 0.00098 \text{ s} = \]

b) \[ 1278 \text{ kg} + 0.42 \text{ kg} + 1.6 \text{ kg} + 9.345 \text{ kg} = \]

c) \[ 1424.1 \text{ m} - 643.09 \text{ m} \]

d) \[ 8.976 \text{ hr} - 0.60309 \text{ hr} = \]
Multiplication and Division:
The answer has the same ________ number of decimal places as the measurement with the ________ number of significant digits.

For example, if we multiply 21.3 cm by 9.8 cm the answer is 210 cm\(^2\) not 208.74 cm\(^2\). Since the measurement with the least number of significant digits, which is ________, has only _____ significant digits, the answer can only have two significant digits.

Perform the following; report your answer to the correct number of significant digits.

a) \(10.4 \text{ m} \times 0.041 \text{ m} = \)

b) \(150.64 \text{ cm} \times 26.987 \text{ cm} \times 0.09976 \text{ cm} = \)

c) \(90.52 \text{ cm} / 2.4 \text{ s} = \)

d) \(9.901 \text{ g} / 3.5 \text{ cm}^3 = \)

Extension:
Why are the addition/subtraction rules different than the multiplication/division rules?
The metric system

Why is the metric system used extensively in science?

The seven base units in the metric system (SI)

<table>
<thead>
<tr>
<th>measurement</th>
<th>unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. How many grams are in a kilogram? __________________________

3. How many meters are in a hectometer? __________________________

4. How many liters are in a dekaliter? __________________________

5. How many milliseconds are in a second? __________________________

6. How many centigrams are in a gram? __________________________

7. How many decimeters are in a meter? __________________________

8. How many centigrams are in a kilogram? __________________________

9. How many milliliters are in a hectoliter? __________________________

10. How many decimeters are in a kilometer? __________________________
Make the following common conversions:

11. \(4008 \text{ g} = \underline{\ldots} \text{ mg}\)  
12. \(48 \text{ ml} = \underline{\ldots} \text{ L}\)

13. \(239 \text{ mm} = \underline{\ldots} \text{ cm}\)  
14. \(2200 \text{ L} = \underline{\ldots} \text{ ml}\)

15. \(38 \text{ kg} = \underline{\ldots} \text{ mg}\)  
16. \(1400 \text{ kg} = \underline{\ldots} \text{ g}\)

17. \(24 \text{ m} = \underline{\ldots} \text{ km}\)  
18. \(148 \text{ m} = \underline{\ldots} \text{ km}\)

19. \(1674 \text{ L} = \underline{\ldots} \text{ ml}\)  
20. \(28 \text{ mm} = \underline{\ldots} \text{ km}\)

21. \(2124 \text{ cm} = \underline{\ldots} \text{ km}\)  
22. \(400 \text{ ml} = \underline{\ldots} \text{ L}\)

**Factor Label Method of Unit Conversion**

A useful method for carrying out unit conversions is called the factor label method. This method makes use two mathematical facts:
- if you multiply any quantity by 1, its value does not change
- any quantity divided by its equivalent is equal to 1

**Example:** Convert \(25 \text{ km/hr}\) (kilometers per hour) to \(\text{m/s}\) (meters per second).

**Solution:** Multiply \(25 \text{ km/hr}\) by a series of factors so that the units you do not want will cancel out and the units you want will remain.

\[
\frac{25 \text{ km}}{1 \text{ hr}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ sec}} = 6.9 \text{ m/s}
\]

23. How many seconds in a year?

24. Convert \(85 \text{ cm/s}\) to \(\text{cm/min}\).

25. Convert \(55 \text{ mi/hr}\) to \(\text{m/s}\). (1 mile = 1600 m)
TRIGONOMETRY NOTES - Consider the powerpoint first

There are three trigonometric identities that are useful in solving for missing sides and angles in right triangles. They are:

\[
\sin \theta = \frac{opp}{hyp} \quad \text{Where: } \theta = \text{an angle}
\]

\[
\cos \theta = \frac{adj}{hyp} \quad \text{hyp} = \text{the hypotenuse}
\]

\[
\tan \theta = \frac{opp}{adj} \quad \text{opp} = \text{the side opposite } \theta \\
\text{adj} = \text{the side adjacent to } \theta
\]

EXAMPLE:

![Diagram of a right triangle with a 40° angle and a side length of 4.0 m.]

Given:
\[
\theta = 40^\circ
\]

\[
\text{adj} = 4.0 \text{ m}
\]

We can determine the hypotenuse using the cos function as follows.

\[
\cos \theta = \frac{adj}{hyp}
\]

\[
\cos 40^\circ = \frac{4.0}{hyp}
\]

\[
hyp = \frac{4.0}{\cos 40^\circ}
\]

\[
hyp = 5.2 \text{ m}
\]

We can determine the opposite side using the tan function as follows.*

\[
\tan \theta = \frac{opp}{adj}
\]

\[
\tan 40^\circ = \frac{opp}{4.0}
\]

\[
opp = 4.0 (\tan 40^\circ)
\]

\[
opp = 3.4 \text{ m}
\]

*of course this side also could have been determined with the Pythagorean theorem or using the sin function.

The missing angle is 50° (90° - 40°), but this could be determined using any of the three functions. BUT REMEMBER if you are calling the 50° angle θ, the 4.0 m side is now opp and the 3.4 m side is now adj.
Fill in each blank:

1. The side opposite angle A is 
2. The side opposite angle B is 
3. The hypotenuse is 
4. The side adjacent to angle A is 
5. The side adjacent to angle B is 
6. The angle opposite side a is 
7. The angle opposite side b is 
8. The angle opposite side c is 
9. The angle adjacent to side a is 
10. The angle adjacent to side b is 

Use a calculator to find each trigonometric ratio rounded to four significant digits

11. $\sin 71^\circ$  
12. $\cos 40^\circ$  
13. $\tan 61^\circ$  
14. $\cos 11.5^\circ$  
15. $\sin 53.45^\circ$  
16. $\tan 17.04^\circ$  
17. $\sin 27.5^\circ$  
18. $\tan 58.72^\circ$

Find each angle rounded to the nearest whole degree

19. $\sin \theta = 0.2678$  
20. $\tan \theta = 0.1046$  
21. $\cos \theta = 0.9237$  
22. $\sin \theta = 0.6748$  
23. $\cos \theta = 0.0628$  
24. $\sin \theta = 0.1102$  
25. $\tan \theta = 1.345$  
26. $\cos \theta = 0.3569$

Solve each triangle (find the missing angles and sides)
Practice

Problems
Mathematics Review

Simplify each expression.

1) \(2a - 7(-8a + 6)\)  
2) \(6(7k - 6) - 5\)

3) \(-4b - 4(4 - 5b)\)  
4) \(6(6 - n) - 7n\)

Simplify. Write each answer in scientific notation.

5) \(\frac{2.4 \times 10^{-2}}{7 \times 10^5}\)  
6) \(1.92 \times 10^1 \cdot 1.8 \times 10^2\)

7) \((1.6 \times 10^{-4}) \cdot (3 \times 10^{-4})\)  
8) \(5 \times 10^{-2} \cdot 6\)

Solve each equation.

9) \(-24 + x = 4(x + 4) + 2x\)  
10) \(-3p - 7(1 - 6p) = -38 + 8p\)

11) \(7b + 8 = 8(1 - 7b)\)  
12) \(-6 - 4(2 - 5m) = -14 + 3m\)

13) \(\frac{-5 + a}{4} = -7\)  
14) \(-12n + 11 = -265\)

15) \(-12 + \frac{a}{3} = -8\)  
16) \(-10(x - 12) = 330\)

Simplify each expression.

17) \((a^4 - 4a^3 - 3) + (5a^4 + 3a^3 + 8)\)  
18) \((k^3 - 3k^2 - 7) - (4k^4 + 2 - 4k^2)\)

19) \((1 + 3x^2 - 8x^3) + (2 - 7x^3 - 3x^2)\)  
20) \((4x^3 - 4x^2 - 1) + (5x^3 - 8x^2 - 2)\)

21) The senior classes at High School A and High School B planned separate trips to the local amusement park. The senior class at High School A rented and filled 2 vans and 11 buses with 454 students. High School B rented and filled 14 vans and 9 buses with 594 students. Each van and each bus carried the same number of students. How many students can a van carry? How many students can a bus carry?

22) The sum of the digits of a certain two-digit number is 12. Reversing its digits increases the number by 36. What is the number?
Practice - algebra

Simplify each expression.

1) \(5(3 + 6k) - 8k\) 
2) \(6(p - 2) + 6p\)

3) \(8(2n + 7) - 6(5 - 8n)\) 
4) \(2(-4 + 6x) + 8x(1 + 2x)\)

Solve each equation.

5) \(23m = -299\)
6) \(\frac{r}{14} = -27\)

7) \(16 = \frac{x}{15}\)
8) \(\frac{46}{39} = \frac{n}{39}\)

9) \(-10v - 8 = 122\)
10) \(2 - 5b = 27\)

11) \(-9(x + 11) = -234\)
12) \(-8(6 + n) = -104\)

Write each answer in scientific notation.

13) \((4 \times 10^{-3})(6.9 \times 10^{-1})\)
14) \((6.51 \times 10^{-1})(7.6 \times 10^{-2})\)

15) \((8 \times 10^{-2})^4\)
16) \(\frac{9 \times 10^{-4}}{5 \times 10^{-5}}\)

Write each number in scientific notation.

17) \(20000\)
18) \(0.05\)

Solve for \(x\) and \(y\)

19) \(5x + 4y = -7\) 
\(y = 7\)

20) \(7x + 8y = 16\) 
\(6x + y = 2\)

21) The school that Kim goes to is selling tickets to the annual dance competition. On the first day of ticket sales the school sold 3 senior citizen tickets and 10 student tickets for a total of $134. The school took in $63 on the second day by selling 1 senior citizen ticket and 5 student tickets. What is the price each of one senior citizen ticket and one student ticket?
FINDING COMPONENTS

Find the $x$ and $y$ components of the following vectors.

1) 22 N west

$x$ - component = 

$y$ - component = 

2) 85 N @ 24° north of east

$x$ - component = 

$y$ - component = 

3) 55 N north

$x$ - component = 

$y$ - component = 

4) 110 N @ 30° west of south

$x$ - component = 

$y$ - component = 

5) 42 lbs @ 50° west of north

$x$ - component = 

$y$ - component = 

6) 75 ft @ 30° east of south

$x$ - component = 

$y$ - component = 
Dimensional Analysis Worksheet

1. 261 g → kg
2. 3 days → seconds
3. 9,474 mm → cm
4. 0.73 kL → L
5. 5.93 cm³ → m³
6. 498.82 cg → mg
7. 1 ft³ → m³
   (Note: 3.28 ft = 1 m)
8. 1 year → minutes
9. 175 lbs → kg
   (Note: 2.2 lb = 1 kg)
10. 4.65 km → m
11. 22.4 kg/L to kg/mL
12. 0.74 kcal/min to cal/sec
13. 1.42 g/cm² to mg/mm²
14. 10095 m/s to miles/s
15. 9.81 m/s² to ft/s²
16. 8.41 g/mL to kg/L
17. 3.8 km/sec to miles/year
18. 7.68 cal/sec to Kcal/min
19. 8.24 g/cm² to mg/mm²
20. 25 m/s to miles/hr

21. Convert $2.05 \times 10^5$ seconds into years.

22. Traveling at 65 miles/hour, how many minutes will it take to drive 125 miles to San Diego?

23. Convert 50 years into seconds. Express your answer in scientific notation.
24. Traveling at 65 miles/hour, how many feet can you travel in 22 minutes? (1 mile = 5280 feet)

25. One sphere has a radius of 5.10 cm; another has a radius of 5.00 cm. What is the difference in volume (in cubic centimeters) between the two spheres? Give the answer to the correct number of significant figures. The volume of a sphere is \((4/3)\pi r^3\), where \(\pi = 3.1416\) and \(r\) is the radius.

26. The total amount of fresh water on earth is estimated to be \(3.73 \times 10^8\) km\(^3\). What is this volume in cubic meters? In liters?

27. Sally Leadfoot was pulled over on her way from Syracuse to Ithaca by an officer claiming she was speeding. The speed limit is 65 mi/hr and Sally had traveled 97 km in 102 minutes. How fast was Sally’s average speed? Does she deserve a ticket?

28. Winnipeg is refilling the pool. How many gallons of water will it take if the pool is 50m by 25m by 1.5m? (1 gallon = 3.786 L)

29. Meredith found some lace at a price of 4.0 £/meter in Ireland that she liked but was afraid she was paying too much for it. The same lace in the United States would sell for $5.99/yd. Was she paying too much for it? ($1 = 0.498 £) (1 yard = 3 ft)

30. At a given point in its orbit, the moon is 2.4 \(\times 10^5\) miles from earth. How long does it take light from a source on earth to reach a reflector on the moon and then return to earth? (Speed of light is \(3.0 \times 10^8\) m/s)

31. In Raiders of the Lost Ark, Indiana Jones tried to remove a gold idol from a booby-trapped pedestal. He replaces the idol with a bag of sand. If the idol has a mass of 2.00 kg, how many litres of sand must he place on the pedestal to keep the mass sensitive booby-trap from activating? (Density of sand is 3.00 g/cm\(^3\))
Practice - vectors

1. Two forces act simultaneously on a point. One force is 5.0 newtons south; the other is 15.0 newtons south. Determine the magnitude and direction of the net force acting on the point.

2. An airplane is heading westward at a velocity of 950 km/hr. The wind is blowing northward with a velocity of 55.0 km/hr. What is the resultant speed and direction of the airplane?

3. Three forces of 120 lbs each all act concurrently on an object. One acts at 45° east of north; another at 45° south of east; and the third west. What is the resultant force?

4. Determine the resultant force when these four forces all act concurrently.

\[ F_1 = 150 \text{ lbs } 62^\circ \text{ above the positive x-axis} \]
\[ F_2 = 130 \text{ lbs in the negative y direction} \]
\[ F_3 = 180 \text{ lbs } 23^\circ \text{ below the positive x-axis} \]
\[ F_4 = 125 \text{ lbs } 55^\circ \text{ below the negative x-axis} \]

5. A girl is hiking in the woods. She walks 2.0 km north, then 3.5 km at a bearing of 25° east of north, then 0.6 km at 10° west of south, and then 2.3 km at 65° north of west. How far did she hike? What is her displacement from where she started? At what bearing should she walk to get back?
1) If you run 24.0 m at 30° east of south, then 28.0 m at 15° south of east, then 17.0 m at 45° west of south, the 19 m north and finally 52.0 m at 10° east of south, what is your resulting displacement? What is the distance you ran?

2) Graph the following data. Discuss the shape and meaning of the graph and write the general equation for the graph. Linearize the graph.

<table>
<thead>
<tr>
<th>Population (millions)</th>
<th>Time (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>45</td>
<td>24</td>
</tr>
<tr>
<td>80</td>
<td>32</td>
</tr>
</tbody>
</table>
3) a. How many minutes are in 2.5 hours?

b. How many seconds are in 1.4 days?

c. How many miles per hour is 15 cm/s (1600 m = 1 mile)

d. 8.0 cubic centimeters per second is how many cubic meters per hour?
Metric Measurement Lab *

Vector Lab *

Homework 1 *

Homework 2 *

Test Review Sheet

* due on the first day of class
**Metric Measurement**

**Background:** Scientists can only expect to communicate effectively if they are using a common "language". While the actual language changes from country to country, the one thing that remains fairly constant is the language of the metric system. Quite surprisingly the United States is not a "metric" nation like most countries. We still use what some consider to be an antiquated "English" system. The beauty of the metric system is that all measurements are based on "10's" making it simpler to convert from unit to unit. The universal "language" of science is based in the metric system and that is the main purpose of this lab experience.

**Purpose:** The purpose of this laboratory experience is:
- to learn to "speak" the universal language of science using metric measurements.
- to learn to convert metric to metric and metric to english/english to metric.
- to get a better "feeling" of just how big a certain unit of metric measure actually is and apply that knowledge when considering units.

**Procedure/Discussion:** There are several prefixes that are associated with metric units that can be attached to the base metric unit in order to create a new metric unit. Knowing the decimal meaning of the prefix establishes the conversion factor relationship between the newly created unit and the base unit.

For example: the prefix "kilo" means $10^3$ or 1,000. Therefore, if we are to use, for instance, a "gram" and we attach the kilo prefix in front, we get "kilogram"

In addition, the relationship between the two units is now more easily understood. Since I know that "kilo" means 1000 then one kilogram unit is the same as (or equal to) $10^3$ "gram" units. The prefixes that are most important are listed below along with their decimal and exponential equivalents:

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Decimal Equivalent</th>
<th>Exponential Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pico-</td>
<td>$0.0000000000001$</td>
<td>$10^{-12}$</td>
</tr>
<tr>
<td>Nano-</td>
<td>$0.000000001$</td>
<td>$10^{-9}$</td>
</tr>
<tr>
<td>Micro-</td>
<td>$0.000001$</td>
<td>$10^{-6}$</td>
</tr>
<tr>
<td>Milli-</td>
<td>$0.001$</td>
<td>$10^{-3}$</td>
</tr>
<tr>
<td>Centi-</td>
<td>$0.01$</td>
<td>$10^{-2}$</td>
</tr>
<tr>
<td>Deci-</td>
<td>$0.1$</td>
<td>$10^{-1}$</td>
</tr>
<tr>
<td>No prefix</td>
<td>1.0</td>
<td>$10^0$</td>
</tr>
<tr>
<td>Deka-</td>
<td>10.0</td>
<td>$10^1$</td>
</tr>
<tr>
<td>Hecto-</td>
<td>100.0</td>
<td>$10^2$</td>
</tr>
<tr>
<td>Kilo-</td>
<td>1,000.0</td>
<td>$10^3$</td>
</tr>
<tr>
<td>Mega-</td>
<td>1,000,000.0</td>
<td>$10^6$</td>
</tr>
<tr>
<td>Giga-</td>
<td>1,000,000,000.0</td>
<td>$10^9$</td>
</tr>
</tbody>
</table>

There are several dozen prefixes used but these above are most commonly used in Science measurements. In this lab we will briefly explore and manipulate the following types of measurement: Mass, Dimension, Volume, and Area.
Mass Measurement

Mass in the metric system has several units that scientists use most often. For comparison, the gram is the standard unit of mass in the metric or SI system. The gram (abbreviated g or gm) is the quantity of matter in an object; it has roughly the same meaning as the English slug (which no one really uses). In physics, we typically use the kilogram.

Weight Measurement

Weight is the measure of the amount of gravitational force an object exerts on the Earth. In the English system, weight is, naturally, measured in pounds (lb). In the Metric system, weight is measured in a unit called the Newton.

Dimensional Measurement

Now let us go over dimensional measurement that is measure of length, width, and height. The basic metric unit of dimension is the meter (m). The meter is analogous to the English yard. A meter is equal to slightly more than a yard (about 10% larger). One meter is equal to 1.09 yards or 39.36 inches. A larger metric unit used often is the kilometer (km) which is analogous to the English mile. One kilometer is equal to 0.62 miles. In countries where the metric system is the national standard, signposts and posted speed limits are in km or km per hour. For example, the most common speed limit in Canada is 100, but that is 100 km/hr or about 60 miles per hour.

All metric rulers are calibrated the same. The numerically numbered position (major calibrations) are equal to centimeter marks, and then there are ten equally spaced position (minor calibrations) in between each of the numbered positions each of which are equal to 0.1 cm(1 mm). According to this calibration, one can record measurements with one position of estimation to the nearest 0.01 cm.

Another instrument most often used in Biology labs is called a micrometer (sometimes referred to as the micron). As the name implies it can measure to the nearest micrometer and is used for very precise measurements of diameters. It is most commonly used in “sizing up” cells under the microscope and is commonly given the symbol “mu”, which looks like: μ

Volume Measurement

The third type of measure is measure of volume. Actually we can break this down into the measure of
1. solid volume (regular and irregular)
2. fluid (liquid and gas) volume

Measurement of Fluid Volumes

Let’s now discuss measure of fluid volume. There are several instruments used to directly measure fluid volumes. The graduated cylinder is the most commonly used in the lab. However, there are several others. The pipet, buret, and volumetric Flask measure fluid volumes more precisely than most graduated cylinders.

The basic metric unit of measure for volume is the liter (L) unit. The liter is similar to the English quart. One liter being the same as 1.06 quarts. It is basically a fluid volume unit as is the smaller metric unit
called the milliliter (mL). The milliliter is similar to the English fluid ounce. One fluid ounce is equal to about 30 mL.

Other metric units of volume that are more often associated with volumes of solids is the cubic centimeter (cc or cm³) which is equal to a milliliter. Be certain that you understand that the cc may look like a dimensional unit since it has the word "centimeter" in it. However, it also has the word "cubic" which always indicates a volume unit.

You can think of a cubic centimeter as a cube 1 cm on each edge. The volume of such a cube would be 1 cm x 1 cm x 1 cm or 1 cm³. We also use the cubic meter (m³) often in science to measure large volumes in space.

Any dimensional relationship such as 100 cm = 1 m can be used to derive a volume unit relationship simply by “cubing” BOTH sides of the relationship so for example:

\[ 100 \text{ cm} = 1 \text{ m cubed would be:} \]
\[ (100 \text{ cm})(100 \text{ cm})(100 \text{ cm}) = (1\text{m})(1\text{m})(1\text{m}) \text{ or } 1 \times 10^6 \text{ cm}^3 = 1 \text{ m}^3 \]

You can even do this with English dimensional relationships that result in a newly created volume relationship. For example:

1 ft = 12 in. If we cubed both sides we would have:
\[ (1 \text{ ft})(1 \text{ ft})(1 \text{ ft}) = (12 \text{ in})(12 \text{ in})(12\text{ in}) \text{ or } 1 \text{ ft}^3 = 1728 \text{ in}^3 \]

Try it yourself on the following dimensional relationships:

If 1 inch = 2.54 cm, determine the relationship between cubic inches and cubic centimeters? Show your work in this space.

Area measurement relationships are similar to volume relationships except you square both sides of the dimensional relationship. For example if we wanted to know the relationship between square cm and square m we could begin with the following dimensional relationship between cm and m:

If: 100 cm = 1 m, then \((100 \text{ cm})^2 = (1 \text{ m})^2 \text{ and } 10,000 \text{ cm}^2 = 1 \text{ m}^2 \)

BASICALLY, dimensional measurement is one dimensional, area measurement is two dimensional and volume measurement is three dimensional.
Data: The following conversion exercises are submitted as data for this laboratory experience:

**METRIC CONVERSION EXERCISES**

Make the conversions within the Metric System and the conversions between the English and the Metric System. Please SHOW ALL WORK AND ALL UNITS to demonstrate that you know what you are doing for conversions between systems.

A. Basic metric equivalencies

See the table at the beginning of this lab or the textbook for further details. The prefixes will be useful.

show all work

1. 1 m = _______ cm
2. 1 m = _______ mm
3. 1 cm = _______ mm
4. 1 km = _______ m
5. 1 km = _______ cm
6. 1 kg = _______ g
7. 1 kg = _______ mg
8. 1 L = _______ mL

B. Conversions between systems - SHOW ALL WORK AND ALL UNITS EXPRESS ALL ANSWERS IN SCIENTIFIC NOTATION

To correctly do this portion of the lab, you must know what the conversions are. As such:

<table>
<thead>
<tr>
<th>English to Metric</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length:</strong></td>
<td></td>
</tr>
<tr>
<td>1 in = 2.54 cm</td>
<td></td>
</tr>
<tr>
<td>1 mi = 1.609 km</td>
<td></td>
</tr>
<tr>
<td><strong>Weight:</strong></td>
<td></td>
</tr>
<tr>
<td>1 lb = 4.44 N</td>
<td></td>
</tr>
<tr>
<td><strong>Mass:</strong></td>
<td></td>
</tr>
<tr>
<td>1 slug = 14.59 kg</td>
<td></td>
</tr>
<tr>
<td><strong>Capacity:</strong></td>
<td></td>
</tr>
<tr>
<td>1 gal = 3.785 L</td>
<td></td>
</tr>
</tbody>
</table>
9. 1 mi = _______ km
10. 1 mi = _______ m
11. 1 yd = _______ cm
12. 50 ft = _______ m
13. 150 lb = _______ N
14. 5 ft 5 in = _______ cm
15. 24 in = _______ cm
16. 1 ft = _______ cm
17. 64 oz = _______ N
18. 1 L = _______ qt
C. multiple unit conversions

19. 55 mi/hr = ________ km/hr

20. 40 mi/hr = ________ km/hr

21. 100 km/hr = ________ mi/hr

22. 20 ft² = ________ in²

23. 14 g/cm³ = ________ kg/m³

24. 18 N/m² = ________ lb/in²

25. 14 cm³/s = ________ m³/hr

show all work
D. dimensional analysis (show all work)

26. The density of mercury is 13.6 g/mL. What is the mass in kilograms of a 2 L commercial flask of mercury?

27. A sample of seawater contains 6.277 g of sodium chloride per liter of solution. How many mg of sodium chloride would be contained in 15.0 mL of this solution?

28. A mole of hydrogen atoms contains $6.02 \times 10^{23}$ atoms. A section of outer space contains 25 atoms. How many moles of hydrogen is this?

29. The speed of light is $3.0 \times 10^{10}$ cm/s. Express this in mi/hr.

30. A doctor orders that a patient receive $1.5 \times 10^{-3}$ mole of sodium chloride. The only solution available contains 1.00 g per 100 mL of solution. A mole of sodium chloride is equivalent to 58.5 g of sodium chloride. How many mL of this solution should the nurse give the patient?
Vector Lab

Objective: How precise is the graphical method of vector addition? How accurate is the graphical method vector addition?

Background Information: Two or more vectors may be added mathematically using trigonometry. The first step is to resolve each vector into its two components (be sure to include the components direction (+/-)). Next find the sum of all the x-components and the sum of all the y-components. Then compute the value of a vector that has those components - this is the resultant.

What is the difference between accuracy and precision?

Procedure: Use the mathematical (component) method to calculate the resultant of the vectors. Use the experimental resultants given and the mathematical resultant as the accepted result to calculate the relative error. The calculations for the first data set are done on the powerpoint on the class page. SHOW AND ATTACH ALL WORK with your conclusion!!

Data:

<table>
<thead>
<tr>
<th>Resultant (experimental)</th>
<th>Resultant (mathematical)</th>
<th>relative error (magnitude)</th>
<th>relative error (direction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 &quot;units&quot; west</td>
<td>15.5 'units' @ 9.7° south of west</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 &quot;units&quot; @ 12° south of west</td>
<td>15.1 'units' @ 11.7° south of west</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 &quot;units&quot; 35° west of north</td>
<td>9.0 'units' @ 10.2° west of north</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 &quot;units&quot; 11° east of north</td>
<td>9.6 'units' @ 8.3° west of north</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 &quot;units&quot; 25° south of east</td>
<td>7.2 'units' @ 63° south of east</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 &quot;units&quot; 45° south of west</td>
<td>7.9 'units' @ 61.4° south of east</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 &quot;units&quot; north</td>
<td>3.1 'units' @ 45.0° east of north</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 &quot;units&quot; 20° south of east</td>
<td>2.8 'units' @ 46.4° east of north</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 &quot;units&quot; 35° west of south</td>
<td>2.9 'units' @ 43.7° east of north</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.8 'units' @ 41.9° east of north</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.0 'units' @ 47.3° east of north</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1 'units' @ 44.4° east of north</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 &quot;units&quot; 85° east of north</td>
<td>3.4 'units' @ 58.3° west of north</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 &quot;units&quot; 15° north of west</td>
<td>3.7 'units' @ 58.1° west of north</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Answer the objective question in the form of a well written conclusion
Add each set of vectors below using trigonometry. For each set, draw a rough sketch (including a reference frame), calculate the components of each vector using the sine and the cosine functions, then add or subtract like-direction components to find the ‘x’ and ‘y’ parts of the resultant and lastly find the magnitude of the resultant using the Pythagorean theorem and the direction using trigonometry.

1. \( d_1 = 18.1 \text{ m} @ 27^\circ \) (or \( 27^\circ \text{ E of N} \))
   \( d_2 = 3.8 \text{ m} @ 275^\circ \) (or \( 85^\circ \text{ W of N} \))

2. \( v_1 = 4.3 \text{ m/s} @ 72^\circ \) (or \( 72^\circ \text{ E of N} \))
   \( v_2 = 10.7 \text{ m/s} @ 247^\circ \) (or \( 23^\circ \text{ S of W} \))

3. \( F_1 = 6.7 \text{ N} @ 306^\circ \) (or \( 54^\circ \text{ W of N} \))
   \( F_2 = 9.2 \text{ N} @ 206^\circ \) (or \( 26^\circ \text{ W of S} \))

4. \( F_1 = 16.2 \text{ N} @ 48.0^\circ \) (or \( 48.0^\circ \text{ E of N} \))
   \( F_2 = 39.6 \text{ N} @ 297.0^\circ \) (or \( 27.0^\circ \text{ N of W} \))
   \( F_3 = 11.2 \text{ N} @ 356.0^\circ \) (or \( 4.00^\circ \text{ W of N} \))
Homework 2
- USE GRAPH PAPER AND GENERATE THE GRAPHS BY HAND
- you can’t generate an excel spreadsheet during the AP Physics I exam
- Don’t play ‘connect the dots’ – draw the best smooth curve or line.

For each set of data generate a graph of the variables, state the relationship between the variables, and if the graph is linear, determine the slope. (Place the bold variable on the horizontal-axis.)
If the graph is a curve, determine what must be plotted to linearize it; plot those values.
Write an equation for each expression.

### a)
<table>
<thead>
<tr>
<th>length</th>
<th>temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.000 m</td>
<td>20°C</td>
</tr>
<tr>
<td>10.002 m</td>
<td>40°C</td>
</tr>
<tr>
<td>10.004 m</td>
<td>60°C</td>
</tr>
<tr>
<td>10.006 m</td>
<td>80°C</td>
</tr>
<tr>
<td>10.008 m</td>
<td>100°C</td>
</tr>
</tbody>
</table>

### b)
<table>
<thead>
<tr>
<th>Number of turns of wire</th>
<th>Number of clips picked up</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>40</td>
<td>12</td>
</tr>
</tbody>
</table>

### c)
<table>
<thead>
<tr>
<th>Car speed (mph)</th>
<th>Stopping Distance (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>240</td>
</tr>
<tr>
<td>40</td>
<td>105</td>
</tr>
<tr>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>20</td>
<td>27</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
</tr>
</tbody>
</table>

### d)
<table>
<thead>
<tr>
<th>Rate of decay (counts/s)</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>30</td>
</tr>
<tr>
<td>1008</td>
<td>60</td>
</tr>
<tr>
<td>507</td>
<td>90</td>
</tr>
<tr>
<td>243</td>
<td>120</td>
</tr>
<tr>
<td>127</td>
<td>150</td>
</tr>
</tbody>
</table>
e) 

<table>
<thead>
<tr>
<th>Pendulum length (cm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>208</td>
</tr>
<tr>
<td>2</td>
<td>146</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
</tr>
<tr>
<td>4</td>
<td>104</td>
</tr>
<tr>
<td>5</td>
<td>92</td>
</tr>
</tbody>
</table>

f) for \( d = \frac{1}{2}(9.8) t^2 \)

<table>
<thead>
<tr>
<th>d (cm)</th>
<th>time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

g) for \( PV = 2.5 \times 10^3 \)

<table>
<thead>
<tr>
<th>P (atm)</th>
<th>V (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td></td>
</tr>
<tr>
<td>125</td>
<td></td>
</tr>
<tr>
<td>84</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

h) \( \frac{9}{d_o} = \frac{h_i}{17} \)

<table>
<thead>
<tr>
<th>( h_i ) (cm)</th>
<th>( d_o ) (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>
1. A submarine dives at an angle of 30 degrees with the surface of the water and takes a straight line path for a total distance of 50 m. How far below the surface is the submarine?

2. A quarterback drops backwards 10 yards from the line of scrimmage, then sideways parallel to the line of scrimmage for 15 yards. If he throws a 50 yard forward pass downfield perpendicular to the line of scrimmage, what is the resulting magnitude of the displacement of the ball?

3. On an extended hike, a camper follows the following path: 100 m east, 300 m south, 150 m @ 30 degrees south of west, and finally 200 m @ 60 degrees north of west. What is the hiker’s resultant displacement?

4. A river flows due east at 1.5 m/s. A boat crossed from the south shore to the north shore by maintaining a constant velocity of 10.0 m/s north relative to the water. What is the velocity of the boat relative to the shore? If the river is 300 m wide, how far downstream has the boat moved by the time it reaches the north shore?

5. Create a graph of the following data:

<table>
<thead>
<tr>
<th>Pressure (Pa)</th>
<th>Volume (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>3.08</td>
</tr>
<tr>
<td>6</td>
<td>4.04</td>
</tr>
<tr>
<td>4</td>
<td>5.97</td>
</tr>
<tr>
<td>2</td>
<td>11.88</td>
</tr>
</tbody>
</table>

What is the shape of the graph? What is the general equation for the graph? What is the relationship between Pressure and Volume? What should be graphed to linearize the graph? Determine the slope of the linear graph.

6. Convert the following measurements:
- 800 grams to kilograms
- 1400 kg/m³ to g/cm³
- 50 mph to m/s (1 mile = 1600 meters)

7. How many significant zeros are in the following measurements?
   a) 0.004503 cm    b) 0.03980407 s    c) 1390 ft    d) 980.040 cm/s

8. Express the answer to the following to the proper number of significant digits:
   a) 88.04 cm \times 14.3 cm    b) 7.925 cm + 123.4 cm    c) 2.4 \times 10^3 m / 8.375 \times 10^{-4} s

9. Lake Michigan holds $1.3 \times 10^{15}$ gallons of water. How many cubic meters is this? (264.2 gal = 1 cubic meter; 1 cubic meter = 1000 L; 1L = 0.946 quarts; 4 quarts = 1 gallon)
10. Consider the following systems of equations

\[ v = at \quad KE = \frac{1}{2} mv^2 \quad d = \frac{1}{2} at^2 \]

What happens to:

a) \( v \) when \( a \) doubles and everything else remains constant?

b) \( KE \) when \( a \) doubles and everything else remains constant?

c) \( d \) when \( v \) doubles and \( a \) remains constant?

\( d \) when \( a \) and \( t \) both half?

e) \( v \) when \( KE \) doubles and \( m \) stays constant?

f) \( a \) when \( KE \) stays the same and \( m \) halves and everything else remains constant?

g) \( KE \) when \( t \) doubles, \( d \) halves and everything else remains constant?

11. For each of the following, identify the independent and dependent variables, plot a graph of the data (remember... put time on the x-axis regardless of whether it’s the independent or dependent variable), state the relationship between the variables, linearize the data (if necessary), write an equation for the graph.

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Time (s)</th>
<th>Pressure (atm)</th>
<th>Volume (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1.0</td>
<td>32.2</td>
</tr>
<tr>
<td>125</td>
<td>5.08</td>
<td>4.0</td>
<td>7.9</td>
</tr>
<tr>
<td>500</td>
<td>10.11</td>
<td>8.0</td>
<td>4.2</td>
</tr>
<tr>
<td>1125</td>
<td>15.3</td>
<td>12.0</td>
<td>2.7</td>
</tr>
<tr>
<td>2000</td>
<td>20.07</td>
<td>16.0</td>
<td>1.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wavelength (m)</th>
<th>Period (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.2</td>
<td>1.0</td>
</tr>
<tr>
<td>12.2</td>
<td>2.0</td>
</tr>
<tr>
<td>18.1</td>
<td>3.0</td>
</tr>
<tr>
<td>24.3</td>
<td>4.0</td>
</tr>
<tr>
<td>30.7</td>
<td>5.0</td>
</tr>
</tbody>
</table>

1) 25 m  2) 42.7 yards  3) 240 m & 37 degrees south of west  4) 10.1 m/s & 8.5 degrees east of north; 45 m
5) hyperbolic; \( y = k/x \); Volume is inversely proportional to pressure; volume versus 1/pressure, \( V = 24 \) PaL
6) 0.8 kg; 1.4 g/cm\(^2\); 22.2 m/s
7) a) one  b) two  c) none  d) three  8) a) 1260 cm\(^2\)  b) 131.3 cm  c) 2.9 \times 10^5 m/s  9) 4.9 \times 10^{13} \text{ m}^3
10) a) doubles; b) quadruples; c) quadruples; d) one-sixteenth as big; e) \( \sqrt{2} \) times as big; f) \( \sqrt{2} \) times as big; g) one-sixteenth as big

11 a) independent = distance, dependent = time; distance is directly proportional to time squared; \( d \) vs \( t^2 \) = linear graph; \( d = 5t^2 \)

b) independent = pressure, dependent = volume; Volume is inversely proportional to Pressure; \( V \) vs \( P \) = linear graph, \( PV \approx 32 \)

c) independent = period, dependent = wavelength; wavelength is directly proportional to period; graph is already linear; \( \lambda = 6.2T \)