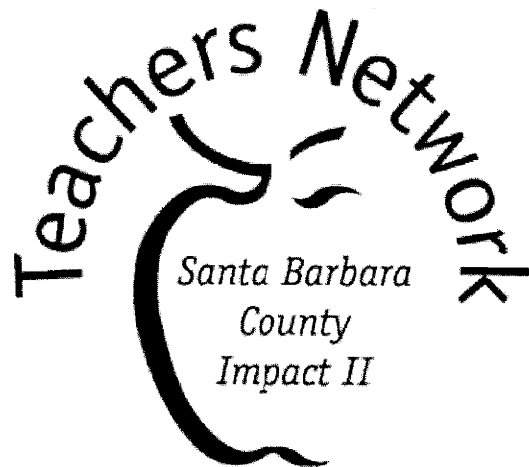


From the Depths of the Sea to Outer Space

Michelle Poquette



2006 Project Grants
Santa Barbara County Education Office

Physical Science

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Course: Integrated Physical Science

Ca State Standards:

ROV, Waves, Electricity, Ecology, Natural Selection, Investigation and Experimentation, Chemistry

Book: Physical Science

Materials you need:

- Pens and pencils
- Composition book - ROV Journal
- Lined paper or another notebook to take notes

Expectations:

- You will be on time every day – in your seat when the bell rings
- You will bring all materials stated above every day
- You will attend class regularly – this is a lab class and there will be **no make ups** for missed labs – EXCEPTION = illness or school event
- **NO LATE WORK WILL BE ACCEPTED!**
- Assignments are to be turned in regularly and on time
- NO horseplay in class especially during labs!
- Do not touch the animals unless given permission
- Use appropriate language at all times
- Respect yourself, your classmates, the classroom and your teacher

Grades: these percentages are approximate and grade also depends on attendance and behavior

<u>Scale</u>	<u>Weighted Grades</u>
100%-90% = A	50% = Tests and Quizzes
89%-80% = B	30% = Labs
79%-70% = C	20% = Homework
69%-60% = D	
59% -below = F	

Make-Up

It is YOUR responsibility to make up missed work from an excused absence. I will not remind you about make up work. You must come to me the day you return (not a week later) to collect missed assignments and notes.

Students will use California State Standards in Physics to design a working underwater ROV. As they complete a unit they will add another portion to their ROV. For example there is a unit on electricity and circuits. Students will attach their motors and assemble the control boxes.

Students are given a work like environment with a group supervisor, recorder and a chief boss (the teacher). They are given strict guideline on aspects of the ROV but the design is up to their imaginations. They are given deadlines, incorporating mathematics and have been keeping a journal of their ROV development as well as creating research papers on real life ROV missions.

ROV – Remote Operated Vehicles

- Students learn California State Standards in Physics then apply those standards into building an ROV.
- Revolving around the theme “From the Depths of the Sea to Outer Space” the Physical Science class is a continuation of the science courses involving laboratory and scientific investigations.
- This has never been done before at Cabrillo High School. The course is called Physical Science and has just finished its second year. Curriculum was developed by Michelle Poquette, science teacher and Cabrillo alumni, and ROV mentoring was provided by Robert Ranard, a district employee and Cabrillo High School’s Official ROV Team Mentor.
- There are four classes with about 9-10 working ROV’s in each class totaling about 130 students and 40 ROV’s
- Students are learning valuable hands on skills that will carry on into their life in the real world. Such as proper wiring, working with electricity, connecting batteries, using electric and hand held tools.
- Students are asked to think “outside the box” and create a project from scratch using their imagination.
- They must learn to work as a team to draw a design, build it, attach motors and perform correct wiring to the battery and successfully operate the ROV under water to perform specific tasks.
- Students must keep a journal of every thing they complete on the ROV and will be interviewed by professionals from NOAA, Santa Barbara City College and UCSB to show their competency in the ROV
- Community businesses have been aiding this course by donating materials. Ace hardware has been the biggest donor, sending us all of the PVC needed for frames. Wal-Mart and NAPA autoparts have donated car batteries to power the ROV’s and Home Depot has supported with tools.

Physical Science Curriculum

“From the Depths of the Sea to Outer Space” Unit

I. The ROV

- A. New tool to study the ocean
- B. ROV History Video
- C. ROV History Timeline – Harry Bohm yellow book pg 6-11
- D. Diving Bell Lab
- E. Marine technology in the Workforce ppt
- F. What is an ROV ppt
- G. ROV Research Internet Lesson
- H. ABYSS video

II. Introduction to science

- A. Scientific Method
- B. Laboratory Techniques
- C. Metric System
- D. Density
- E. Buoyancy

III. ROVS

- A. Frame design, sketch and build
- B. Motor and electrical attachments
- C. Buoyancy Tests – floatation
- D. Tether wiring
- E. Control boxes
- F. Testing and pool practice
- G. Competition (Dec 7th and 8th this year)

IV. Electricity – This unit will be introduced between III.C and D

- A. Static Electricity and conservation
 - a. Positive and negative charges
 - b. Opposite charges attract
- B. Friction, Induction, Conduction
- C. Direct Current Electrical Circuits
 - a. Electrical potential Difference
 - b. Resistance
 - c. Ohm’s Law
 - d. Simple direct current circuits
 - e. Series Circuits
 - f. Parallel Circuits

ROV Parts List

- Select group members
- 2-3 in group no larger
- Max of 10 groups
- Team name
- Journal
 - First page is title page in journal
 - Every day we work on ROV you do a journal entry
 - Completeness – should fill at least ½ a page for every entry
 - Neatness counts!
 - Date and title every page

Building your ROV

35 tall cm x 35cm wide x 40 cm long

You have the following parts of 40 grade PVC

2 in

4in

6in

8in

10 in

2 in

45 degree elbow coupler

90 degree elbow coupler

T coupler

X coupler

Straight pieces- coupler

Black electrical tape

String

Pipe foam insulation

Speaker wire-30ft (we use wire that connects computer to network as long as it has pos and negative for at least 3 connections)

Copper wire- black (negative) red (positive)

Water proof silicon tube

2 Medium (orange)

12 small l(grey) wire nuts

Plastic storage bin

2 battery connectors

Grey plastic electrical box with lid

3 three-way toggle switches

3 motors – Mayfair 400GPI bildge pump caratarige (Bass Pro Shops)

3 propellers

9 #6 ½ inch stainless steel screws

Car battery

DONATIONS

The following Community members have made donations noted below to the Cabrillo High School Physical Science class. These donations aided 130 students in building 40 working underwater remote operated vehicles or ROV's.

Additional funding can from our schools SSP grant for the Marine Technology Institute, however these funds have ran out at the end of the 2005-2006 school year

Ace Hardware – donated over \$1000.00 in PVC pipe and connections for ROV frames, discounted the price of switches for the control boxes

Home Depot - \$50 in PVC connections and tools

Wal-Mart - \$50 in rubber maid storage bins to store ROV's, and 5 brand new car batteries from their auto department to power ROV

NAPA auto parts – donated 3 brand new car batteries to power ROV

Bass Pro Shops – 40% discount on 120 motors to run ROV

Dumas Products – 10% discount on 300 1.25" nylon propellers

NOAA – Donated T-shirts and hats as Prizes for ROV competition

UCSB – Donated binders, stickers, T-shirts, mugs and pencils as prizes for ROV competition

Cabrillo ASB/PTSA – Donated 4 Cabrillo High school sweatshirts as prizes

Cabrillo Marine Technology Institute (MTI)– donated 4 \$50 checks as prizes

Cabrillo Aquarium Club – donated 4 \$40 best buy gift certificates

Building the ROV's
STEPS

1. Group assignment
 - a. Recommend no more than 3 per group when ever possible
 - b. Team name
 - c. ROV Journal – composition books
 - i. Every time they work on the ROV they must have a journal entry
 - ii. Title, date and page number on every page
 - iii. Neatness counts in individual grade
 - iv. One book will be selected from group to be entered into the contest
 - v. Go over contest and requirements
 - vi. Go over parts list – first journal entry
2. Individual sketch
3. Group rough sketch
4. To scale final sketch
5. Building the frame
 - a. Have groups build frame and tare down for the first 2 days
 - b. On third day they build and keep what they build
 - c. Pass out plastic bins with a sticker- students put their team name on sticker then place on bin
 - d. DO NOT STORE journals in bin- they will get wet
6. Attaching the motors
 - a. Drill a hole through each motor flap and pipe where is will be attached on ROV
 - b. Attached with #6 ½” stainless steel screw
 - c. One motor should be up and down and the other two should be side by side facing forward or backwards
 - d. Best to attach motors on two T coupler ends for best support.
7. First buoyancy test
 - a. Hold the ends of the wire s outside the water test your ROV for balance and buoyancy
 - b. Use foam pieces of pipe insulation to obtain slightly possitive buoyancy
8. Wiring motors – refer to diagram in back
 - a. Negative to negative (black on motors to white with stripe on tether)
 - b. Positive to positive (brown on motors to solid color on tether)
 - c. Connect with a grey wire nut
 - d. Eventually the wire nuts will be stuffed in a silicone filled water proofing tube – but don't do this yet! You want to test the whole unit first!
9. Control Box

- a. Drill three holes big enough in lid to mount the three toggle switches
 - b. Wire back side of switched as shown in the diagram in the back. Make sure screws are tight! And that you double check each box otherwise it will short, catch on fire and melt and the group will have to start all over again!
10. Connect all three negative (black) switch motor control wires (the ones crossed) to the tether – remember to pull tether through a pre drilled hole on side of box first! – use grey wire nuts
11. Connect all three positive (red) switch motor control wires to tether. – use grey wire nuts
- a. Pre drill 2 other holes on other side of box for thick red and black battery wire connections, string through holes, –
 - i. group together all the side black wires from switched and connect to black battery wire with a orange wire nut
 - ii. group together all the side red black wires from switched and connect to red battery wire with a orange wire nut
 - iii. attach batter connectors to other ends of battery wires
12. TEST –
- a. hook up positive battery wire to positive terminal of car battery
 - b. make sure the switches are all off
 - c. hook up negative wire to negative terminal of car battery
 - d. Run a quick test on each motor forwards and reverse by moving toggle switches.
 - e. IMPORTANT – do not run the motors out side of water more than a second or two. They need water to cool down and you could damage the motors – DO NOT PLACE IN WATER AT THIS TIME IT IS NOT WATER PROOF YET!
 - f. Trouble shoot any problems by checking all connections!
13. WATER PROOFING
- a. The control box should never get wet
 - b. After you have a successful test and all motors are working you should inset the tether-motor connection in to the silicone filled tube- top off with silicone and seal
 - c. Then do another test as wire could come loose during this process
 - d. Tidy up wires and attach silicone tube with black electrical tape neatly in a center location on the ROV
14. Buoyancy test – You need to do a final buoyancy test adding or taking away any foam until the ROV is very slightly positively buoyant – just floating at the top of the water
15. PRACTICE PRACTICE PRACTICE

ROV CONTEST AND RULES

Obstacle course

- You have a 20 minute time period
- You must hook up your ROV and do a quick water test within the first 5 minutes
- At this point the timing judge will let you know when to start. You will start by having your ROV out of water set on the ground. When the Timing judge says "GO" you may place your ROV in the water
- You have 10 minutes to pick up 2 pool rings, maneuver through the obstacle course.
- The rings can be picked up at the same time or one at a time. You must bring the rings to the surface and have a group member retrieve them without touching the ROV itself.
- If you touch the ROV intentionally a 10 second penalty will be placed on your final time.
- The judge will let you know when your time is up.
- If you have not completed your task within the time limit you will be given an automatic 10min time score
- If you complete in less than 10 minutes your time score will be better.
- The best time score on the obstacle course, between all four periods, will be the winner.
- A grade will be determined by me, involvement of each group member and completeness of mission as well as problems solving if anything goes wrong.

Interview

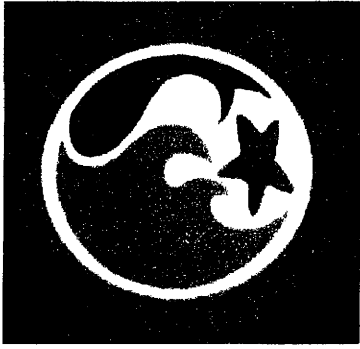
- Your team will be asked 5 basic questions about your ROV
- The judge will choose who will answer the question
- You will be given a score between 1 and 10 on how thorough and complete your answer is.
- You may not talk with the rest of your team to come up with an answer or you will be given a 0 for that question.
- An average between the judge's scores will be taken and that will be your interview score. This will also be the team's grade in this section of the ROV.

Relay race

- Each team member will be required to drive across the short end of the deep pool (there and back). You will then switch with another member. A time will be taken. The fastest time in each period will be the winner

Tug of war

- Process of elimination – 2 random teams will be tied together. You get 60 seconds to "tug"
- The winner pulls the other ROV stronger.
- The loser will be eliminated and the winner will compete against the next person



Cabrillo High School



Presents

2nd Annual Inter-class ROV Competition

December 6th and 7th

7:45am-2:30pm

At Cabrillo High School Pool



You are invited to watch as 40 student built ROV's compete in obstacle courses, professional interview, relay race and tug of war contest

Call Cabrillo at 742-2888 and ask for Michelle Poquette, Science teacher, for any questions.

Per1 -Wed Dec 7th

Group Name	Obstacle course time	Relay Race Time	Interview Score	Tug of war Winner
MOC				
Jabeaite				
KKM				
Steve				
Team 32				
Numa Numa				
Philabeite				
The M				
Immigrants				
Northern Lights				
Orange Potatoes				

Per 2 - Wed Dec 7th

Group Name	Obstacle course time	Relay Race Time	Interview Score	Tug of war Winner
Tornado Timmy				
Ninja Turtles				
Armadillo Backs				
Wonder Boys				
Soka				
Lasagna				
Lucky Charms				
Chicken Wing Trio				
Penguins				

Interview Form

Group Name _____

#	Question	Score	Comments
1	What types of things did you think about when developing your design?	1 2 3 4 5 6 7 8 9 10	
2	Did you have any major obstacles or problems and how did you fix them?	1 2 3 4 5 6 7 8 9 10	
3	If your up- down motor suddenly cuts out what would you check to try to fix it?	1 2 3 4 5 6 7 8 9 10	
4	How did you deal with buoyancy of your ROV?	1 2 3 4 5 6 7 8 9 10	
5	What is the most important thing that you think you gained or learned from doing this project?	1 2 3 4 5 6 7 8 9 10	
Other		1 2 3 4 5 6 7 8 9 10	
Other		1 2 3 4 5 6 7 8 9 10	
Other		1 2 3 4 5 6 7 8 9 10	
	Journal Overall Score	1 2 3 4 5 6 7 8 9 10	
	TOTAL SCORE		
	% Average		

NEW TOOLS TO STUDY THE OCEAN

TENDING VESSEL^a VEHICLES*

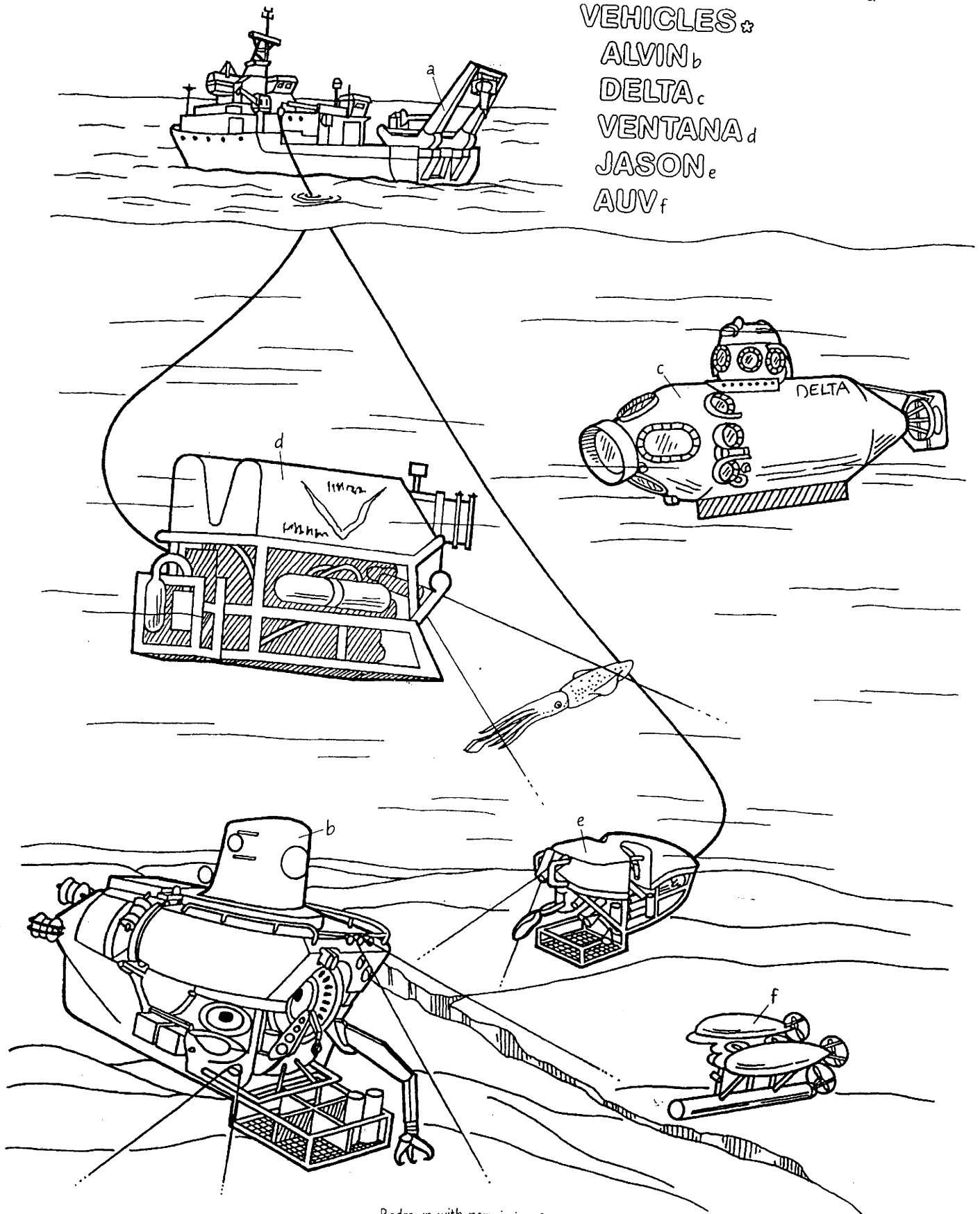
ALVIN^b

DELTA^c

VENTANA^d

JASON^e

AUV^f



NEW TOOLS TO STUDY THE OCEAN

Historically, marine scientists have explored the depths of the ocean second hand, using various kinds of nets and dredges. To sample the deepest ocean bottom, these heavy, clumsy pieces of gear would have to be lowered and recovered great distances through the water column, sometimes requiring 24 hours to collect a single sample. The organisms sampled would sustain considerable damage and disfigurement from the changes in pressure and from being compacted in the net. The softer, more delicate organisms would often disintegrate and pass through the net, never to be seen.

Color the tending vessel on the surface. Then, color each oceanographic vehicle as it is mentioned in the text. The vehicles are not drawn to scale.

In the latter quarter of the twentieth century, new tools have been developed to study the ocean. Mini-submersibles with substantial depth capabilities allow scientists to observe deep-sea animals first hand. *Alvin*, Woods Hole Oceanographic Institution's (WHOI) pioneering (1964) workhorse submersible, has been joined by a number of deep-diving vessels. *Alvin* has undergone substantial modification and retrofitting over its long career and even survived a sinking mishap that occurred when sea water poured into its open hatch during a botched launching. *Alvin* was retrieved from the deep-sea bottom by a nuclear submarine belonging to the United States Navy, and went on to be instrumental in the discovery of the Galapagos hydrothermal vent communities (Plate 17) and in locating the final resting place of the ill-fated *Titanic*.

For shallower work, smaller, lighter submersibles, like Delta Oceanographics' *Delta*, have been perfected that do not require a tending vessel for monitoring, launching, and retrieval. Only a standard ship's winch is required to launch and retrieve *Delta*. This small sub operates on battery power and can dive all day on an overnight charge to depths up to 400 meters (1300 ft). *Delta* has been involved in many oceanographic studies and helped locate HMS *Lusitania*, which was sunk in shallow water by German U-boats off the coast of Scotland.

Remotely operated vehicles (ROVs) are not hampered by on-board human limitations, and have become an invaluable tool in the scientist's quest for an understanding of the sea. It is estimated that 98 percent of the ocean can be reached by this new generation of vehicles. ROVs are equipped with several small electric motors that allow speed

and maneuverability, which can be precisely controlled by a pilot on the *tending vessel* above via an oceanographic cable. High resolution video cameras provide crystal clear images of what the ROV is "seeing" for the pilot and scientists, and at the same time, record the images for later reference. ROVs, like the *Ventana* of Monterey Bay Aquarium Research Institute, can also capture midwater and bottom animals, some in special pressurized traps that allow the animals to be studied intact on the surface. Navigating through poorly studied depths, the ROVs have made truly pioneering observations of the behaviors of midwater animals, and have discovered scores of previously unknown species.

ROVs are sometimes used in tandem with manned submersibles. WHOI's small, maneuverable ROV, *Jason* is often sent into tight quarters to get a "closer look" with its video camera for *Alvin*.

The latest oceanographic vessels brought into play are the autonomous underwater vehicles (AUVs). These small, relatively inexpensive vehicles (\$16,000 to \$50,000 plus, depending on installed equipment, compared to millions for an ROV) are computer programmed and sent down untethered to perform various tasks and observations. Successful operations to date have utilized sidescan sonar to map bottom topography, water column profilers such as fluorometers to measure chlorophyll, and thermal sensors to measure temperature. Chores such as mapping specific sections of the ocean's bottom or measuring temperature fields around hydrothermal vents can be accomplished inexpensively. AUVs can be programmed to resurface for collection or to communicate via two-way satellite links with shore-based researchers to transmit data and receive directions. In 1996, a pair of AUVs was successfully operated in a coordinated study of the mixing of two water currents. At the end of each day of the study, data from the AUVs were downloaded and integrated into an elaborate model of the current system, and new sampling profiles were generated and programmed into the AUVs for the next day's operation. One future plan calls for the long term stationing of AUVs in place on the bottom of the ocean, programmed to return to a bottom docking site to recharge, and then continue their programmed data gathering. Initial experimentation with such a system has gone well, and innovative technology that will allow long distance underwater communication and control of AUVs is now being tested. AUVs stand poised to play a major role in the future study of the oceans.

Name
Period

Diving Bell Lab write – up

1. List materials Needed

2. List procedures for construction and for operation

Answer the following questions

3. What happened when you first put the bottle in the water with your thumb covering the tube? _____
Explain your answer WHY? _____

4. What happened when you took your thumb off the tube? _____
Explain your answer WHY? _____

5. How fast did the bottle descend? _____
6. How did you get the bottle to return to the surface? _____
7. Could you get your bottle to hover 10 cm (5 in) under the water? _____
8. How did you complete question # 7? _____

9. If we had a mouse in the bottle what are some things that would he have to deal with as the bottle went down? _____ how about when it went back up again? _____

ROV Research Paper

1. Find a particular ROV or ROV mission on the internet. Alvin, Delta, Curv, US Navy Deep Drone, Ventana, ROVDOG, ROPOS, Tiburon, *Voyager*, (the Perry Tritech ROV), Navy NR-1. These are just a few. Also try scientific websites like NOVA and Discovery.
2. Write a research paper (intro, body and conclusion) 2-3 pages typed 12 font 1.5 spacing.
3. Your paper should include the following information
 - Name of ROV and what it stands for
 - Pilot of ROV and rest of crew
 - Who owns the ROV
 - What type of ROV is it and what is it+ mainly used for?
 - What missions has it gone on.
 - Pick one mission to detail on. Include where it took place, why it took place, what was the purpose, and what were the results.
 - Has this ROV had any major problems or experienced any accidents.
 - Any other major information that could be included in this paper about this ROV
4. This paper will be graded on the following
 - Contents – does it have all of the above information
 - Grammar- run on sentences, sentences that make sense, or fragmented sentences, wording, proper use of words etc...
 - Spelling- use spell check and have someone else other than you proof read your draft, you fix the problems then have someone proof read the final draft again before you turn it in.
5. You will receive a **0 grade** for the whole paper if it is **plagiarized**. That means if you cut and paste words off the internet into your document!!!
6. This paper is worth **40 points**
7. DUE: **Friday December 3rd**– you have 2 weeks but don't wait until the last minute
8. **No late papers** will be accepted if you know that you will not be here that Friday you must turn it in early. You may turn in your papers earlier or give them to me to proof read for you. If you want me to proof read I need the paper no later than Tuesday Nov 30. I will not proof read after this day.

<http://www.pbs.org/wgbh/nova/abyss/>

- A. Click on "The mission"
- B. Click on "Birth of an Expedition"
 - 1. What is the name of the ROV driver? _____
 - 2. What is his mission? _____
 - 3. Where are they completing the mission? _____
 - 4. Why do scientists want to study black smokers? _____
 - 5. What year and where were thermal vents first discovered? _____
 - 6. What is a black smoker? _____
- C. Click back
- D. Click on Mission "Plan"
 - 7. What is the name of the ROV used? _____
 - 8. What day did the ROV enter the water? _____
 - 9. What day was the first chimney recovered? _____
 - 10. How many chimneys were collected? _____
 - 11. What day did they return to Seattle? _____
- E. Click back
- F. Click "Dispatches"
- G. Click "ROPOS Guys"
 - 12. What caused the accident and how deep was it? _____
- H. Click back
- I. Click Dive 440"
 - 13. What went wrong on the ROV? _____
- J. Click back
- K. Click "Phang"
 - 14. What is Phang? _____
- L. Click back twice – you should be on the main page
- M. Click on "Through the portholes" Check out the pictures
- N. Click back
- O. Click on "Meet the Team"
 - 15. List the team members and their titles _____
 - _____
 - _____
 - _____

P. Click on "Keith Shepherd"

16. Summarize Keith's answer to the question "Is ROPOS ideal suited for this mission?" _____

17. Summarize Keith's answer to the question "How would you rate your job as far as jobs go?" _____

Q. Click back twice

R. Click on "Meet ROPOS"

18. What does ROPOS stand for? _____

19. How deep can it dive? _____

S. Click on Five Function Arm on the picture of ROPOS

20. List all the things it can do. _____

21. How many pounds can it lift? _____

T. Click back twice – you should be on the main page

U. On the left hand side there is a column of titles. Click on "Life in the Abyss"

V. Click on "Deep Sea Bestiary" check out the creatures found in the Abyss

W. Click back to return to main page

X. On the left hand side there is a column of titles. Click on "Last Frontier"

Y. Click on "Deep Sea Machines"

22. How many types are shown _____ Notice how they
change overtime and for function needed.

Z. Click Back and then click Deep Sea Vents"

23. Where are the most vents found

Pacific _____

Atlantic _____

REINFORCEMENT

Standards of Measurement

Fill in the missing information in the table below.

SI prefixes and their meanings	
Prefix	Meaning
	0.001
	0.01
deci-	0.1
	10
hecto-	100
	1000

Circle the larger unit in each pair of units.

1. millimeter, kilometer
2. decimeter, dekameter
3. hectogram, decigram
4. centimeter, millimeter
5. hectogram, kilogram

6. In SI, the base unit of length is the meter. Use this information to arrange the following units of measurement in the correct order from smallest to largest. Write the number 1 (smallest) through 7 (largest) in the spaces provided.

- | | |
|---------------------|---------------------|
| _____ a. kilometer | _____ e. hectometer |
| _____ b. centimeter | _____ f. millimeter |
| _____ c. meter | _____ g. decimeter |
| _____ d. dekameter | |

Use your knowledge of the prefixes used in SI to answer the following questions in the spaces provided.

7. One part of the Olympic games involves an activity called the decathlon. How many events do you think make up the decathlon? _____
8. How many years make up a decade? _____
9. How many years make up a century? _____
10. What part of a second do you think a millisecond is? _____

Physical Science- SI Measurement skills

Name _____

1. Length

- a. Your height in _____ mm _____ cm _____ m
- b. Length and width of your ID _____ x _____ mm
_____ x _____ cm _____ x _____ m

2. Mass

- a. Two nickels _____ g _____ kg
- b. One quarter _____ g _____ kg
- c. Ten pennies _____ g _____ kg
- d. One pencil _____ g _____ kg
- e. Your mass _____ g _____ kg

3. Temperature

- a. Room temperature _____ C _____ K
- b. Temperature of your hand _____ C _____ K
- c. Temperature of ice water _____ C _____ K

4. Time

- a. The time you can hold your breath _____ min _____ s
- b. Your estimation of how long 15 seconds is _____ s

5. Volume

- a. Volume of cube(LxWxh) _____ cm³ _____ m³
- b. Volume of marble _____ cm³ _____ m³

6. Density

- a. Density of cube _____ g/cm³
- b. Density of marble _____ g/cm³
- c. Density of 1 penny _____ g/cm³
- d. Density of 1 nickel _____ g/cm³
- e. Density of 1 quarter _____ g/cm³

Skills Worksheet

Math Skills**Conversions**

After you study each sample problem and solution, work out the practice problems on a separate sheet of paper. Write your answers in the spaces provided.

Problem

Armando stepped on the scale in his doctor's office and found out that his mass is 35 kg. What is his mass in grams?

Solution

Step 1: List the given and unknown values.

Given: mass in kilograms = 35 kg

Unknown: mass in grams = ? g

Step 2: Determine the relationship between units. By using the table below, you know that 1 kg = 1000 g. You will multiply because it takes a lot of grams to make up each kilogram.

Step 3: Write the equation for the conversion.

$$\text{mass in g} = \text{mass in kg} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

Step 4: Insert the known values into the equation, and solve.

$$\text{mass in g} = 35 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

$$\text{mass in g} = 35\,000 \text{ g}$$

Prefix	Symbol	Meaning	Multiple of base unit
<i>mega-</i>	M	million	1000 000
<i>kilo-</i>	k	thousand	1000
<i>deci-</i>	d	tenth	0.1
<i>centi-</i>	c	hundredth	0.01
<i>milli-</i>	m	thousandth	0.001
<i>micro-</i>	μ	millionth	0.000 001

Practice

- On March 24, 1989, the *Exxon Valdez* struck a reef in Prince William Sound, Alaska, spilling 37 854 120 L of crude oil. What is this volume in milliliters?
-

Problem

At 553 m tall, the CN Tower, in Toronto, Canada, is one of the tallest structures in the world. What is the tower's height in kilometers?

Solution

Step 1: List the given and unknown values.

Given: *height in meters* = 553 m

Unknown: *height in kilometers* = ? km

Step 2: Determine the relationship between units. Using the table on the previous page, you can see that 1000 m = 1 km. You will divide because there are fewer kilometers than meters in a given distance.

Step 3: Write the equation for the conversion.

$$\text{height in km} = \text{height in m} \times \frac{1 \text{ km}}{1000 \text{ m}}$$

Step 4: Insert the known values into the equation, and solve.

$$\text{height in km} = 553 \text{ m} \times \frac{1 \text{ km}}{1000 \text{ m}}$$

$$\text{height in km} = 0.553 \text{ km}$$

Practice

4. One of the smallest species of insects in the world is *Caraphractus cinctus*, a type of wasp. The average mass of this wasp is 5 μg . Convert this mass into grams.
-

Problem

There are 60 minutes in an hour. What is this amount of time in seconds?

Solution

Step 1: List the given and unknown values.

Given: *time in minutes* = 60 min

Unknown: *time in seconds* = ? s

Step 2: Determine the relationship between units. Although minutes do not fit strictly in the SI system, they can be used with it. Note that there are 60 seconds in a minute. You will multiply because there are many seconds in each minute.

Step 3: Write the equation for the conversion.

$$\text{time in s} = \text{time in min} \times \frac{60 \text{ s}}{1 \text{ min}}$$

Practice

11. The purpose of the sport called *flight archery* is to shoot an arrow the greatest possible distance. One of the greatest distances achieved in flight archery is 624 m. What would this distance be in centimeters?

Problem

One of the largest emeralds ever discovered had a mass of 17.23 kg. Assuming its density to be 4.02 g/cm³, what was the emerald's volume?

Solution

Step 1: List the given and the unknown values.

Given: *mass*, $m = 17.23 \text{ kg}$
 density, $D = 4.02 \text{ g/cm}^3$

Unknown: *volume*, $V = ? \text{ cm}^3$

Step 2: Rearrange the density equation to calculate for volume.

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$\text{volume} = \frac{\text{mass}}{\text{density}}$$

$$V = \frac{m}{D}$$

Step 3: Insert the known values into the equation, and solve.

$$V = \frac{17.23 \text{ kg}}{4.02 \text{ g/cm}^3} \times \frac{10^3 \text{ g}}{\text{kg}}$$

$$V = 4.29 \times 10^3 \text{ cm}^3$$

Practice

6. Magnesium is a fairly light metal that is combined with other elements to form lightweight alloys for use in airplanes. The big advantage of magnesium is that it has a relatively low density of 1.74 g/cm³. If a sample of magnesium has a mass of 9.56 g, what is its volume?

Problem

Lithium is the lightest of metals and the least dense of all nongaseous elements. A pure lithium sample with a volume of 13.0 cm³ has a mass of 6.94 g. What is the density of lithium?

Solution

Step 1: List the given and the unknown values.

Given: *mass*, $m = 6.94 \text{ g}$
 volume, $V = 13.0 \text{ cm}^3$

Unknown: *density*, $D = ? \text{ g/cm}^3$

Step 2: Write equation for density.

$$\text{density} = \frac{\text{mass}}{\text{volume}} \qquad D = \frac{m}{V}$$

Step 3: Insert the known values into the equation, and solve.

$$D = \frac{m}{V} = \frac{6.94 \text{ g}}{13.0 \text{ cm}^3}$$

$$D = 0.534 \text{ g/cm}^3$$

Practice

11. Outer space is often described as a vacuum, but there is always some matter present. In the space 300 km above Earth's surface, there is as little as $1.58 \times 10^{-12} \text{ g}$ of matter in a 500.0 cm³ volume of space. Based on this data, what is the density of the matter in space?

Fill in the following table and answer the following questions

1. What is the equation for density? _____

object	mass	volume	density
cork			
rubber stopper			
blue marble			
white marble			
black marble			
5 copper BBs			
silver cube			
brass cube			
silver bar			
water			
oil			
corn syrup			

2. Which objects or liquids above will float due to their densities?

3. Which object or liquids above will sink due to their densities?

4. Rate the solid object from least dense to most dense

5. Rate the liquids from least dense to most dense

Chapter 13 Forces in Fluids

Section 13.3 Buoyancy

(pages 400–404)

This section discusses buoyancy and Archimedes' principle of factors that determine whether an object will sink or float in a fluid.

Reading Strategy (page 400)

Summarizing As you read about buoyancy, write a brief summary of the text following each green heading. Your summary should include only the most important information. For more information on this Reading Strategy, see the **Reading and Study Skills** in the **Skills and Reference Handbook** at the end of your textbook.

Buoyant Force	Buoyant force is the apparent loss of weight of an object submerged in a fluid.
Archimedes' Principle	The buoyant force on an object is equal to the weight of fluid it displaces.
Density and Buoyancy	Objects less dense than the fluid they are in, float. Objects denser than the fluid they are in, sink. When the buoyant force is equal to the weight, the object floats or is suspended. When the buoyant force is less than the weight, the object sinks.

Buoyant Force (page 400)

1. What is buoyancy? _____
2. Circle the letter of the correct answer. In which direction does a buoyant force act?
 - a. in the direction of gravity
 - b. perpendicular to gravity
 - c. in the direction opposite of gravity
 - d. from above the fluid
3. Is the following sentence true or false? The greater a fluid's density, the greater its buoyant force. _____
4. Buoyancy causes an apparent _____ of weight of an object immersed in a fluid.
5. Circle the letter of each sentence that is true about buoyancy.
 - a. Forces pushing up on a submerged object are greater than the forces pushing down on it.
 - b. Forces acting on the sides of a submerged object cancel each other out.
 - c. Gravitational forces work together with buoyant forces.
 - d. The net buoyant force is non-vertical.

Chapter 13 Forces in Fluids

Archimedes' Principle (page 401)

6. According to Archimedes' principle, the weight of fluid displaced by a floating object is equal to the _____ acting on that object.
7. Is the following sentence true or false? When an object floats partially submerged in a fluid, it displaces a volume of fluid equal to its own volume. _____

Density and Buoyancy (pages 401–404)

Match each description with the correct property. Properties may be used more than once.

- | Description | Property |
|--|------------------|
| _____ 8. This property is the ratio of an object's mass to its volume, often expressed in g/cm^3 . | a. weight |
| _____ 9. This force is equal to the force of gravity that acts on a floating object. | b. buoyant force |
| _____ 10. When this property is greater for an object than for the fluid it is in, the object sinks. | c. density |
| _____ 11. These two forces act on every object in a fluid. | |
| _____ 12. An object will either float or be suspended when the buoyant force is equal to this. | |
13. Use what you know about density and buoyancy to predict whether each of the substances listed in the table will float or sink in water. The density of water is $1.0 \text{ g}/\text{cm}^3$.

Will It Float or Sink?		
Substance	Density (g/cm^3)	Float or Sink?
Gold	19.3	
Balsa Wood	0.15	
Ice	0.92	
Brick	1.84	
Milk	1.03	
Gasoline	0.70	

14. How is a heavy steel ship able to float?
- a. Because the density of steel is $7.8 \text{ g}/\text{cm}^3$.
 - b. The ship's shape enables it to displace a large volume of water.
 - c. Because the density of water is $1 \text{ g}/\text{cm}^3$.
 - d. The ship's effective density is greater than that of water.

Chapter 13 Forces in Fluids

WordWise

Solve the clues to determine which vocabulary words from Chapter 13 are hidden in the puzzle. Then find and circle the terms in the puzzle. The terms may occur vertically, horizontally, or diagonally.

h y a r a u l i c s y s t e m
 v a h u s p i a c f r h y e b
 s r q a z f f r e r v d c q
 p c i u y t t p r e s s u r e
 t h d f r g s f l u t m a o e
 k i u b p l o e k i h t u f z
 k m t y u i r f l u i d l t d
 v e k p o o p f v b n m i n m
 o d k a r p y o i m q c c a f
 p e g s y h z a v b n h s y b
 p s e c u h n j n n l o m o q
 l r i a j u e r t v f d u a
 p o i l m j g b h f y u j b o

Clues

Mathematician who discovered that the buoyant force on an object equals the weight of the fluid displaced by the object

The result of a force distributed over an area

Type of substance that assumes the shape of its container

Ability of a fluid to exert an upward force on an object within it

SI-unit of measure used to express pressure

Upward force that keeps an aircraft aloft

Device that uses pressurized fluids acting on pistons of different sizes to change a force

Force that opposes the weight of an object floating in a fluid

Hidden Words

Physical Science- SI Review

Name _____

Write the base unit for each measurement

1. Length _____
2. Mass _____
3. Temperature _____
4. Time _____
5. Volume _____
 - a. Solid _____
 - b. Liquid _____
6. Write the symbol and how much it is worth for the following
 - a. Kilo _____, _____
 - b. Hecto _____, _____
 - c. Deka _____, _____
 - d. BASE _____, _____
 - e. deci _____, _____
 - f. centi _____, _____
 - g. milli _____, _____
 - h. micro _____, _____
 - i. nano _____, _____
7. What is the equation for Density _____
8. What is the equation to solve for mass _____
9. What is the equation to solve for volume _____
10. Convert the following
 - a. 50 Km-m _____
 - b. 50 Hm-m _____
 - c. 50 Dm-m _____
 - d. 50 m-dm _____
 - e. 50 m-cm _____
 - f. 50 m-um _____
 - g. 50 m-nm _____
 - h. 50 Dm-dm _____
 - i. 50 um-nm _____
 - j. 50 Km-mm _____
 - k. 50 mm-cm _____

11. Convert to scientific notation

- a. 3567 _____
- b. .00378 _____
- c. 3982.345 _____
- d. .0000378 _____
- e. 90 _____

12. Convert the following back to normal

- a. 5.689×10^6 _____
- b. 8.93×10^{12} _____
- c. 1.234×10^3 _____
- d. 3.7×10^{-7} _____
- e. 9.77×10^{-1} _____
- f. 4.65×10^{-4} _____

13. Solve the following problems

- a. $m=4.5\text{g}$ $V=89\text{ cm}^3$ find density _____
- b. $m=68.9\text{g}$ $V=514\text{ cm}$ find density _____
- c. $m=56.9\text{g}$ $D=1.234\text{ g/cm}^3$ find volume _____
- d. $m=300\text{g}$ $D=3.45\text{ g/cm}^3$ find volume _____
- e. $V=23.5\text{cm}^3$ $D=2.098\text{ g/cm}^3$ find mass _____
- f. $V=6.9\text{ cm}^3$ $D=.834\text{ g/cm}$ find mass _____

14. Define the following

- a. Buoyancy
- b. Buoyant force
- c. Archimedes's principle

15. Answer the following questions about the diagram on the board

- a. Which diagram has the greatest buoyant force
- b. Which diagram has the least buoyant force
- c. Which diagram has an object with the greatest density (liquids are the same)
- d. Which diagram has an object with the least density (liquids are the same)
- e. Which diagram has a liquid with the least density (objects are the same)
- f. Which diagram has a liquid with the greatest density (objects are the same)

Skills Worksheet

Concept Review

Section: Electric Charge and Force

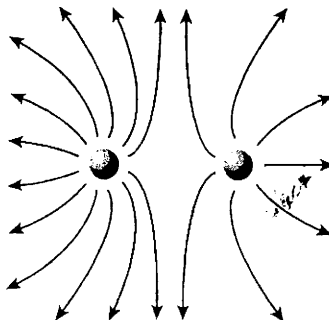
1. Describe the interaction between two unlike charges.

2. Determine the amount by which the electric force between two charges is increased when the distance between the charges is halved.

3. Categorize the following as conductors or insulators:

- _____ a. salt water
- _____ b. a silver belt buckle
- _____ c. a piece of wood
- _____ d. a penny
- _____ e. a candy bar

4. Determine whether each charge in the diagram below is positive or negative. Indicate which charge is greater.



5. Suppose the electric field in a region points upward.

a. Determine the direction of the electric force on a proton placed in the field.

b. Determine the direction of the electric force on an electron placed in the field.

c. Compare the accelerations of the proton and electron placed in this electric field.

Concept Review

Section: Current

1. State the condition that is necessary for a charge to move in a wire.

2. Explain how connecting an electric device to a battery produces a current in the device.

3. Relate the definition of electric current to the units of current.

4. Describe the cause of resistance and how the resistance of a wire can be determined.

5. Calculate the voltage required to produce a current of 2.0 A in a wire with a resistance of 16Ω .

6. Calculate the amount of current in your fingers if they touch the terminals of a 12 V battery when the resistance of your skin is 650Ω .

7. Compare superconductors and semiconductors with conductors and insulators.

Skills Worksheet

Math Skills**Resistance**

After you study each sample problem and solution, work out the practice problems on a separate sheet of paper. Write your answers in the spaces provided.

Problem

A clothes dryer is equipped with an electric heater. The heater works by passing air across an electric wire that is hot because of the current in it. The wire's resistance is 10.0Ω , and the current in the wire equals 24 A . What is the voltage across the heater wire?

Solution

Step 1: List the given and unknown values.

Given: *resistance, $R = 10.0 \Omega$*

current, $I = 24 \text{ A}$

Unknown: *voltage, $V = ? \text{ V}$*

Step 2. Write the equation for resistance, and rearrange it to solve for voltage.

$$R = \frac{V}{I} \qquad V = IR$$

Step 3. Insert the known values into the equation, and solve.

$$V = (10.0 \Omega) \times (24 \text{ A})$$

$$V = 240 \text{ V}$$

Practice

1. A hair dryer uses a wire that is hot because of the current in it to warm the air that blows through the dryer. The resistance of this wire is 7.7Ω . If the current through the wire equals 15.6 A , what is the voltage across the terminals of the hair dryer?

2. A battery-powered electric lantern is used as a light source for campers. The light bulb in the lantern has a resistance of 6.4Ω . Assume the rest of the lantern's circuit has no resistance and that the current in the circuit is 0.75 A . Calculate the voltage across the terminals of the lantern's battery.

Math Skills *continued*

3. Some kitchen sinks are equipped with electric garbage disposals. These are units with rapidly rotating steel blades that crush and chop food so that it can be washed down the drain instead of taking up space as solid garbage. The motor of a garbage disposal has a resistance of about 25.0Ω . If the current in the motor is 4.66 A , what is the voltage across the motor's terminals?
-
4. A washing machine motor works because of a current of 9.80 A in a circuit with a resistance of 12.2Ω . What is the voltage across the terminals of the motor?
-
5. A flashlight uses three batteries of equal voltage. The batteries are connected in series, so the overall voltage of the light is equal to the sum of the voltages of each battery. If the resistance of the light bulb's filament is 3.5Ω and the current in the filament is 1.3 A , what is the total voltage across the filament? What is the voltage across each battery?
-

Problem

An electric car is equipped with a motor that can deliver 50 hp . The voltage across the motor's terminals equals $5.0 \times 10^2 \text{ V}$, and the resistance in the motor's circuit is 7.5Ω . How large is the current in the motor?

Solution

Step 1: List the given and unknown values.

Given: voltage, $V = 5.0 \times 10^2 \text{ V}$

resistance, $R = 7.5 \Omega$

Unknown: current, $I = ? \text{ A}$

Step 2: Write the equation for resistance, and rearrange it to solve for current.

$$R = \frac{V}{I} \qquad I = \frac{V}{R}$$

Step 3: Insert the known values into the equation, and solve.

$$I = \frac{5.0 \times 10^2 \text{ V}}{7.5 \Omega}$$

$$I = 67 \text{ A}$$

Math Skills *continued*

Practice

6. A quadraphonic car stereo operates on electricity provided by the car's 12-V battery. Each channel of the stereo, which feeds the electric signal to one of the stereo's four speakers, has a resistance of about 4.1Ω . What is the current in the circuit of each stereo channel?
-
7. When resistors are connected end to end in a circuit, they are said to be in series. The total resistance equals the sum of all the resistances. Suppose a string of lights has 25 bulbs. Each bulb has a resistance of 8.0Ω . If the string is plugged into a 120-V outlet, how much current is in the entire set of lights?
-
8. A chandelier has 10 sockets, each of which holds a 60.0-W light bulb. Each light bulb has a resistance of 240Ω . However, the chandelier is wired so that the overall resistance provided by the 10-bulb circuit is only about 24.0Ω . If the voltage across the chandelier's circuit is 115 V, how much current is in the chandelier?
-
9. A window-unit air conditioner has an overall resistance of 22Ω . If the voltage across the air conditioner equals 115 V, what is the current in the air conditioner's circuit?
-

Problem

A television set is plugged into a 120-V outlet. The current in the television is equal to 0.75 A. What is the overall resistance of the television set?

Solution

Step 1: List the given and unknown values.

Given: *voltage, $V = 120 \text{ V}$*
 current, $I = 0.75 \text{ A}$

Unknown: *resistance, $R = ? \Omega$*

Step 2: Write the equation for resistance.

$$R = \frac{V}{I}$$

Math Skills *continued*

Step 3: Insert the known values into the equation, and solve.

$$R = \frac{V}{I} = \frac{120 \text{ V}}{0.75 \text{ A}}$$

$$R = 160 \ \Omega$$

Practice

- 10.** A medium-sized household oscillating fan draws 0.520 A of current when the potential difference across its motor is 120.0 V. How large is the fan's resistance?
-
- 11.** A refrigerator's circuit has a current equal to 0.647 A in it when the voltage across the circuit equals 116 V. What is the resistance of the circuit?
-

Mixed Practice

- 12.** A portable high-intensity lamp contains three bulbs with different power ratings: 150 W, 300 W, and 500 W. The resistance of each of these light bulbs decreases as the bulb's power output increases so that the 150-W bulb has a resistance of 96.0 Ω , the 300 W bulb has a resistance of 48.0 Ω , and the 500-W bulb has a resistance of 29.0 Ω . If the voltage across each bulb is 120.0 V, what is the current in each bulb?
-
- 13.** You have probably heard that high voltages are more dangerous than low voltages. To understand this, assume that your body has a resistance of $1.0 \times 10^5 \ \Omega$. What voltages would have to be across your body to produce a current of 5.0 mA (milliamps, or 0.001 A), which would cause a tingling feeling; 10.0 mA, which would be a fatal amount of current; and 1.0 A?
-
- 14.** While in another country, you should always find out the voltage that is used in that country before you plug in an appliance. To understand the reason for this precaution, calculate the resistance of a laptop computer that is designed to draw 3.0 A at 115 V. Then calculate the current that the same computer would draw if you plugged it into a 220-V outlet, which is common in countries other than the United States.
-

Cross-Disciplinary

Electric Shock: Caution!

Read the following paragraphs, and complete the exercises below.

Current, voltage, and resistance are three basic terms used to describe electricity. Current is the rate at which electricity flows. Voltage is the force that causes the electricity to flow. Resistance is the property that slows the flow of electricity through a conducting material.

THE PATH OF LEAST RESISTANCE

Electricity always travels the path of least resistance. The path of least resistance is a good conductor, such as a metal, any wet material, or the human body. Dry skin gives some resistance to the flow of electricity. However, if the skin is wet—especially from sweat—the resistance drops dramatically.

ELECTRIC SHOCK CAN HAVE A WIDE RANGE OF EFFECTS

If you touch a “live” wire while you are touching the ground or standing on another conductor that is touching the ground, electricity will flow through you and you will be shocked. Electric shock can be a mild tingle or a deadly jolt. The effect is determined by how much current flows through the body and where it goes. The small amount of electricity used by one Christmas tree bulb can kill a person if it passes through a vital organ.

Exercises

1. Two children riding bicycles come to a downed power-line pole that blocks their way. The line is not broken and a small bird sitting on the line seems fine. Can the children assume that the line is safe for them to pick up and move aside? Why or why not?

2. A certain electric tool comes with a ground wire that users should attach to a path to the ground. How is the ground wire a safety precaution?

3. An electric wire has burned through and fallen on top of the clothes dryer. If you are careful not to touch the wire, would it be safe to open the dryer door to remove the clothing? Why or why not?

Cross-Disciplinary**Electric Eels**

Read the following paragraphs, and complete the exercises below.

Electric eels are found in the Amazon, Orinoco, and other muddy rivers in the tropical regions of South America. They grow as large as 2.75 m (9 ft) long and weigh up to 22 kg (49 lb). Electric eels are one of the few animals that can make, store, and discharge electricity. Electric eels use this electricity to navigate, communicate, stun or kill their prey, and defend themselves.

ELECTROPLAQUES

You can understand how an eel generates electricity by imagining its body as a series of batteries. An eel's body contains an organ that produces electricity. This organ is made up of 5000 to 6000 special muscle cells called electroplaques. The electroplaques are lined up like cells in a dry battery. Each electroplaque produces only a small voltage. However, eels can activate all of their electroplaques at the same time and produce a much higher voltage. When electric eels discharge electricity, the current flows either from head to tail or in the opposite direction. The more electroplaques that are activated, the greater the discharge.

Electric eels have more than one level of discharge. They generally discharge about 25 to 75 V, but when they discharge from all the electroplaque cells at the same time, they can jolt the receiver with as much as 500 to 650 V of electricity.

Exercises

1. Would the size of an electric eel influence the amount of volts that it could discharge? Why or why not?

2. How does the highest discharge of an electric eel compare with the voltage that comes out of a normal wall socket?

3. Would it be dangerous for a human to be in the water near an electric eel that discharged a jolt of electricity to stun a large fish? Why or why not?

Using a Lemon as a cell

Name _____

Materials:

Knife

juicy lemon

copper

tin

zinc

lead

aluminum

2 alligator clips

galvanometer (measures for volts)

Purpose: Because lemons are so juicy, their juicy acts like an electrolyte. If various metals are inserted into a lemon to act as electrodes, the lemon can be used as an electrochemical cell. We will see how well a lemon works as a battery and to see what material conduct the best.

Procedure:

1. using a knife, make two parallel cuts 6 cm apart along the middle of the lemon
2. insert the various strips as asked for on the table
3. Attach one alligator clips to each metal, (don't connect them together)
4. Attach the other ends to the different terminal of the Galvanometer.
5. record the volts on the table.
6. Create a graph of your results.

Table

Metals	Galvanometer reading (V)
Zinc - Zinc	
Zinc - Copper	
Zinc - Aluminum	
Zinc - Tin	
Zinc - Lead	
Copper - Copper	
Copper - Aluminum	
Copper - Tin	
Copper - Lead	
Aluminum - Aluminum	
Aluminum - Tin	
Aluminum - Lead	
Tin - Tin	
Tin - Lead	
Lead - Lead	