FireScience
workbook 2

FireScience

A Resource for Science Teachers

A free educational publication
by NSW Rural Fire Service

Secondary students

A publication of NSW Rural Fire Service

INTRODUCTION

Every single person in our community is connected in one way or another with fire. Fire may be disastrous in that it destroys our belongings and interrupts our way of life or fires may be beneficial by providing us with an energy source which we can use to prepare meals, keep us warm, transport us and our goods and maintain our standard of living. Developing a better understanding of the nature and behaviour of fire will enable us to maximise the benefits and minimise the disastrous effects of fire. ■ It is within this context that FireScience provides learning experiences through which students can acquire scientific knowledge, skills and attitudes within a conceptual framework to facilitate the application of their understanding to everyday life. FireScience aims towards developing a fire sensible population that will be well informed about fire behaviour, management and safety. ■ This student based activity book relates many of the scientific concepts of fire behaviour and management to the Syllabus Core of the NSW Science Syllabus in order to promote fire consciousness into the teaching of science. Science provides a medium in which many of the fire safety concepts introduced in primary school can be continued into the later years at school.

CONTENTS

WORKBOOK 1

1. AIR & GASES

2. MATTER

3. MATERIAL SCIENCE

4. ACIDS AND BASES

5. FIRE AND THE HUMAN BODY

6. WEATHERING AND EROSION

WORKBOOK 2

7. MOTION

8. COMMUNICATION

9. ENERGY AND HEAT

10. ELECTRICITY

11. WEATHER

12. ENVIRONMENT

motion

SYLLABUS CORE CONTENT AREAS INCLUDED IN THESE EXERCISES ARE:

5.12 (a) describe qualitatively the relationship between force, mass and acceleration

(b) explain the relationship between speed, displacement and time

(d) analyse common situations involving motion in terms of Newton's laws

4.20.1 (a) recognise friction as a contact force, which always acts to oppose motion

(b) identify everyday situations where friction acts in response to the applied force

INERTIA

Inertia is the property of a body to remain at rest or to continue in motion until an outside force acts upon it.

Inertia causes you to:

- Be forced back into the seat of a car when it accelerates.
- Move towards the windscreen of the car as it brakes.
- Fall off the top of a fire truck if it changes its motion or direction of travel.

INERTIA AND ACCIDENTS

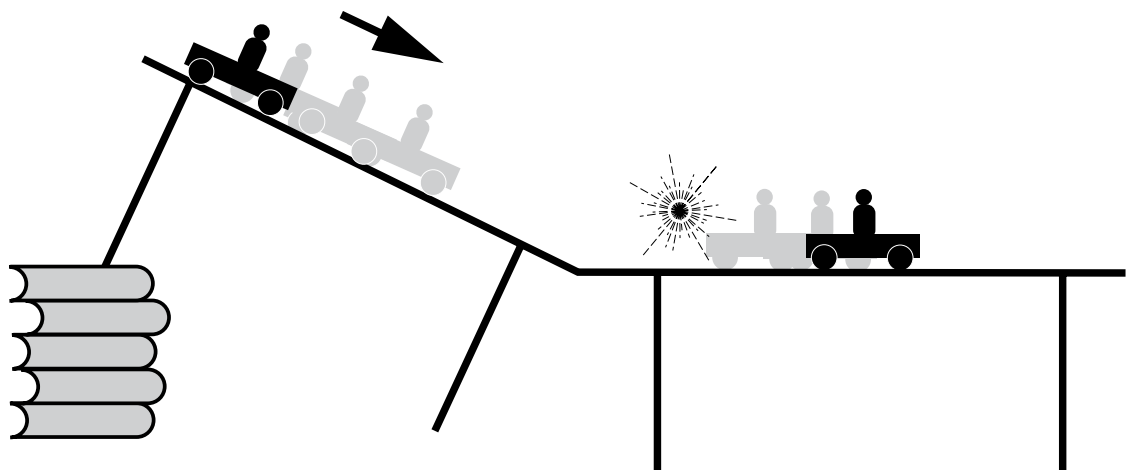
AIM

To simulate the effect of inertia on an unrestrained body in a car accident.

METHOD

you will need; • **2 dynamic trolleys** • **plasticine** • **a couple of old science text books**

- Construct 2 plasticine dummies, which can be placed onto the trolleys.
- Place the old science textbooks under the legs of the desk.
- Place the trolleys as shown in the diagram.
- Release one trolley and allow it to collide into the second trolley.



RESULTS

What happened to the dummy on...

TROLLEY 1 ?

.....

.....

TROLLEY 2 ?

.....

.....

CONCLUSION

Why do the dummies move in this way?

DUMMY 1

.....

.....

DUMMY 2

.....

.....

FURTHER INVESTIGATION

If the plasticine dummies were real, what sort of injuries might they have?

.....

.....

.....

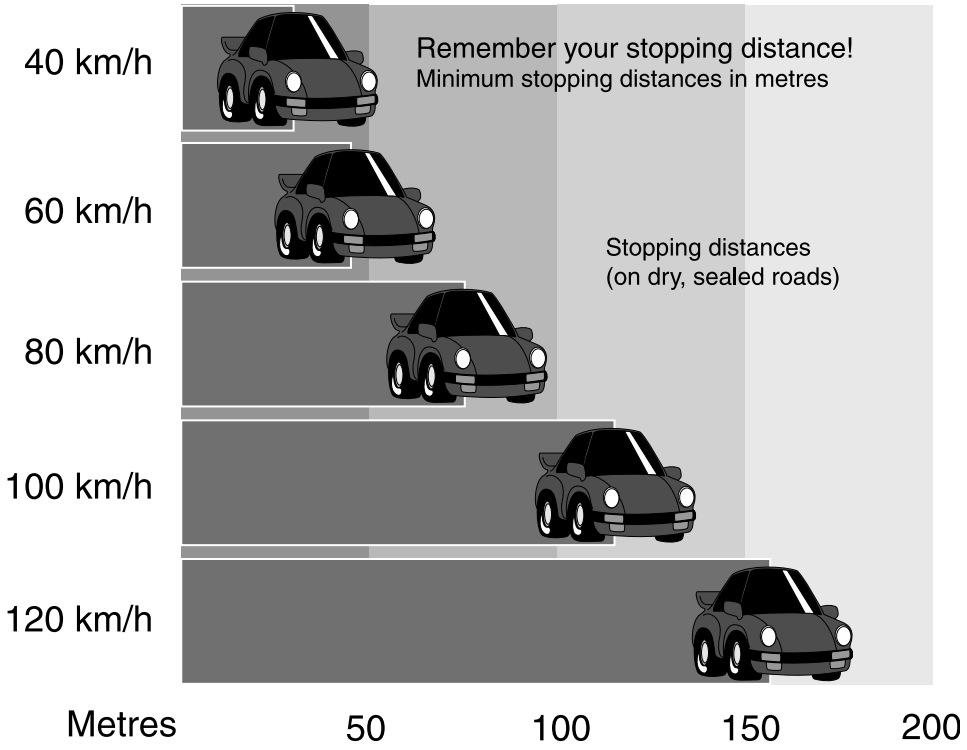
Most cars nowadays have seat belts, head restraints and air bags fitted as safety features. These features are designed to lessen the impact of inertia on the human body. Do all drivers use their seat belts? .....

Imagine that you are in charge of the Rural Fire Service and one of your tasks is to send out a directive to all Rural Fire Service personnel about the use of seat belts and riding on vehicles.

Design a simple LOGO and /or newsletter to show that you “mean business” about the compliance to your directive and Standard Operating Procedure (SOP).

STOPPING DISTANCES

The following diagram indicates stopping distances for cars and light vans under ideal conditions on level ground.



Heavy vehicles such as fire tankers may need two or three times this distance to stop. Suggest some reasons for this.

Re-draw the above diagram to show the stopping distances for heavy fire tankers and other heavy vehicles.

The stopping distances may be doubled again in wet weather. Use a different colour on both tables to show the stopping distances in wet weather.

SPEED

Average speed is the total distance travelled by an object divided by the time taken to travel that distance. It is measured in kilometres per hour or metres per second.

$$\text{AVERAGE SPEED (S)} = \frac{\text{DISTANCE TRAVELLED (D)}}{\text{TIME TAKEN (T)}}$$

$$S = \frac{D}{T}$$

This can be changed around so that:

$$D = S \times T$$

or

$$T = \frac{D}{S}$$

Old Bonalbo Rural Fire Brigade is called to attend a fire, which is 24 kilometres away from the fire shed. If the brigade's tanker averages 60 km/h on the journey, how long will it take to get to the fire? (show all of your working)

.....

.....

.....

.....

.....

EFFECT OF WIND ON FIRE BEHAVIOUR

Wind speed is one of the most important factors in determining fire behaviour in dry fuels. Any fire burning in dry fuel will be relatively easy to control providing winds remain calm. What other factor(s) might affect fire intensity?

.....

.....

.....

.....

.....

Once wind speed increases, the whole range of fire behaviour increases dramatically. As a group discuss and list at least three ways in which wind speed affects a fire:

- .....
- .....
- .....

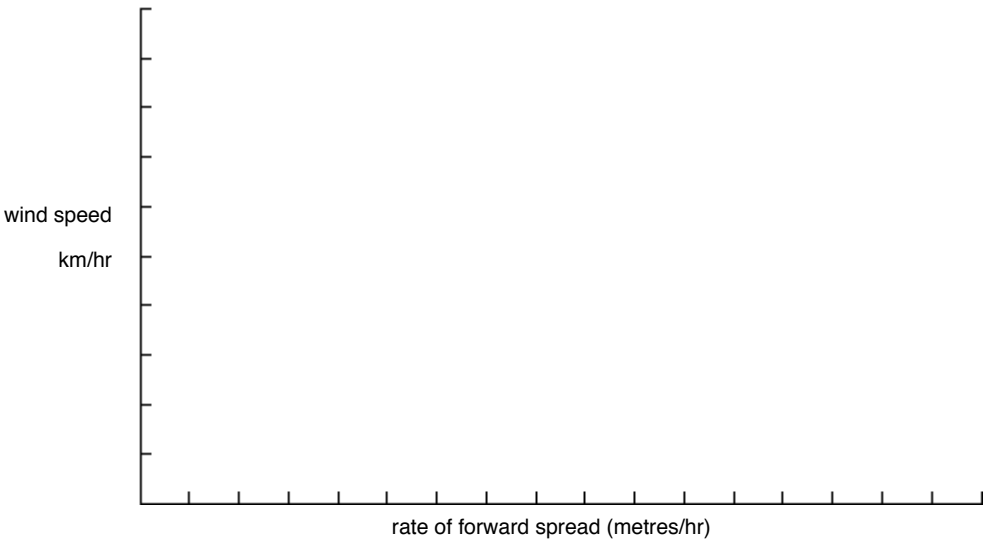
(you might like to use some of these words as clues)

tilts, contact, oxygen, momentum, blow, embers, spotting

The following table shows the relationship between wind speed and rate of forward spread in forest fires.

wind speed in forest (km/h)	rate of forward spread (metre/h)
1	3
2	3
3	3
4	
5	145
6	
7	230
8	
9	380
10	
11	540
12	
13	750
14	

- Plot this information onto the axes below



1. Above what speed will the rate of spread of the fire increase very rapidly with further increases in wind speed?

.....

2. Suggest some reasons for increased wind speed near the ground.

.....

.....

.....

3. On the 7th January 1994 in Sydney the wind speed was 40 km/hr with gusts up to 50 km/hr. Predict from the graph what the rate of forward spread of the fires burning in that area would have been? .....

Convert your answer from metres/hr into km/hr. .....

4. Use the graph to calculate the missing figures in the table. Include your answers in the table.

RUNNING AWAY FROM A FIRE

AIM

Be able to run away from a fire coming in my direction on a critical fire day such as was experienced in Sydney on 7th January 1994?

METHOD

Calculate the average speed at which you can walk, jog and sprint.

(record how long it takes you to cover a measured distance, then divide the distance covered by the time taken)

$$\text{SPEED} = \frac{\text{DISTANCE COVERED}}{\text{TIME TAKEN}}$$

walking

	distance covered	time taken	speed
1			
2			
3			
average			

jogging

	distance covered	time taken	speed
1			
2			
3			
average			

sprinting

	distance covered	time taken	speed
1			
2			
3			
average			

From your answer to question 3. in the previous set of exercises, the speed at which a fire will spread on a day such as 7th January 1994 is .....

CONCLUSION

1. Some factors which will affect 7th January 1994 rate of spread are: .....

.....

.....

.....

2. Looking at your average speeds, would you be able to outrun a fire on a day such as this? .....

3. If you were to recalculate your speed under different conditions eg.

- through an obstacle course
- up a steep hill
- carrying a load
- through the bush,

how would your answer in (2) change? .....

.....

.....

.....

.....

.....

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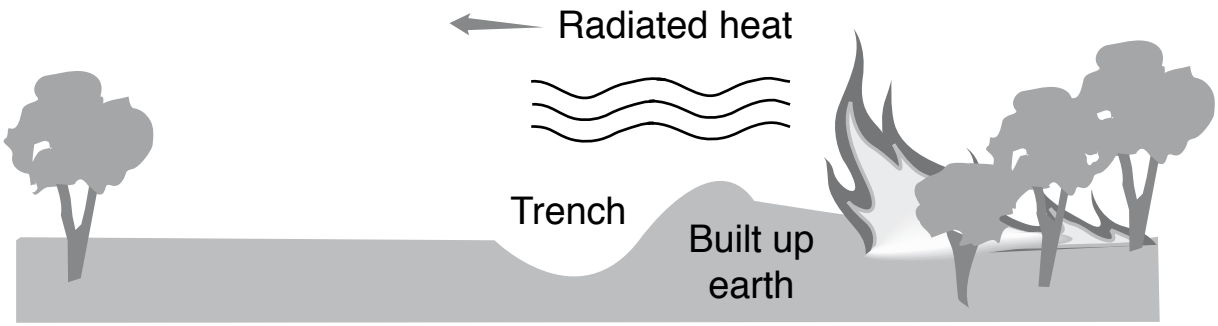
.....

.....

Thorough planning should result in you never being faced with a life-threatening situation, however fire behaviour is often unpredictable.

If suddenly threatened by a fire when you are in the open, move onto bare or open ground if available. Do not run uphill or away from the fire unless you know a safe refuge is handy. Preferably move around the slope of the hill out of the path of the fire.

Scrape a shallow refuge (the deeper the better) or shelter in a natural hollow, behind a shield or in a river or a pond. Lay face down on the ground and cover as much of your body as possible so as to protect yourself from radiated heat.



HOW FAST DOES WATER COME OUT OF A HOSE?

AIM

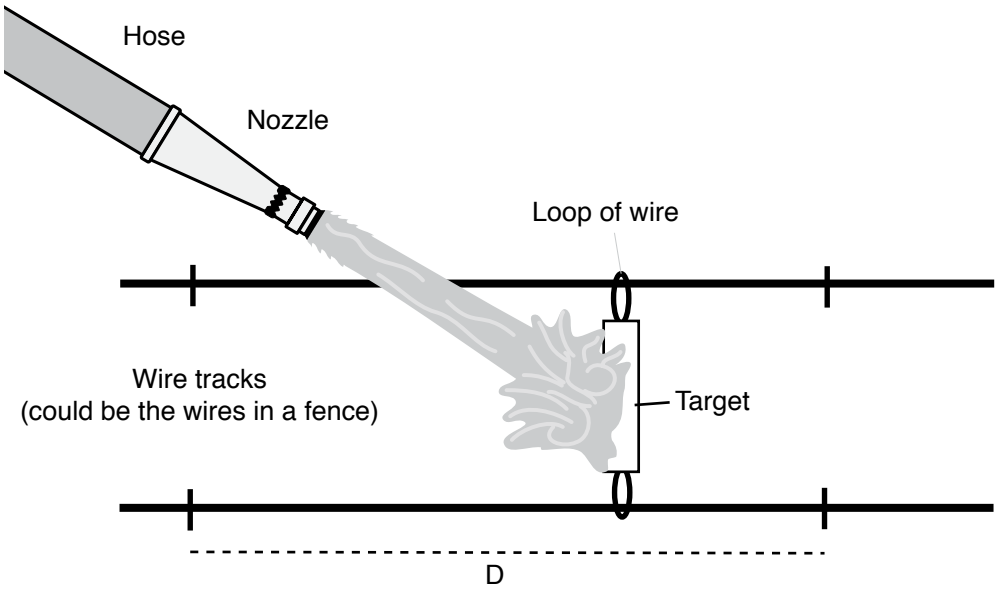
To compare the speed at which water comes out of a hose under various nozzle settings.

(check to ensure that water restrictions are not in force)

METHOD

You will need:

- garden hose with a variable nozzle
- stop watch
- wire metal “target”



1. Set up the target as shown in the diagram.
2. Measure out the distance “D”.
3. Hold the nozzle a set distance away from the target.
4. Switch on the tap and direct the nozzle at the target. The target should slide along the wire over the distance “D”.
5. Record the time taken for the target to cover the distance.
6. Repeat this several times and find the average time taken.
7. Repeat the procedure using different nozzle settings.
8. If you know someone in your local Rural Fire Brigade you might be able to repeat the experiment using the fire tanker hose.
9. Calculate the speed of the water coming from each nozzle setting.

RESULTS

The distance “D” covered by the target each time was .....

trial number	time taken	nozzle setting 1	nozzle setting 2	nozzle setting 3
1				
2				
3				
average				

Using nozzle setting 1 the average speed of the water was: ..... m/s

Using nozzle setting 2 the average speed of the water was: ..... m/s

Using nozzle setting 3 the average speed of the water was: ..... m/s

CONCLUSION

1. What happens to the opening of the nozzle when the speed of the water increases?

   .....

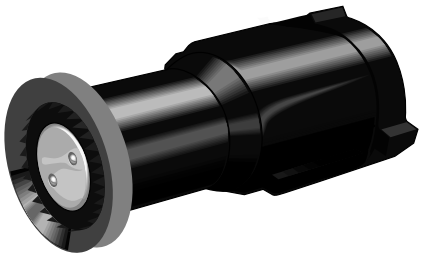
2. Does increasing the speed also increase the volume of the water coming from the hose? (you may like to test this by collecting the water in a bucket and comparing the volumes obtained with different nozzle settings)

   .....

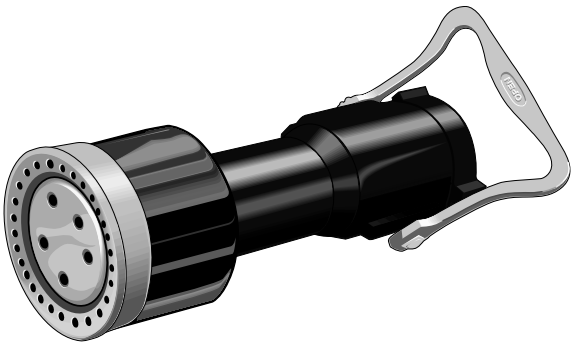
   .....

   .....

The following diagrams show two variable nozzles used by the Rural Fire Service. You should be able to recognise the outlets which provide high speed jets of water.



Typical variable nozzle



Typical multi-outlet nozzle

FRICTION

Friction is a force which tends to oppose motion. Friction tends to change moving or kinetic energy into heat energy.

where friction is needed	place where we want to reduce friction
how we increase friction	**how we decrease friction**

Teacher: Demonstrate to the rest of the class the correct method used to strike a match.

Does the matchbox have a fire safety message? .....

If a water pump is left running but no taps are switched on, the same water stays in the pump and may become very hot and can in some cases boil. Suggest some reasons for this: .....

.....

.....

A bearing in an electric motor overheats and starts a small fire in the motor. How can a bearing in a motor be prevented from overheating? .....

.....

.....

WHICH TYRES ARE BEST?

AIM

To compare a variety of tread patterns on a range of tyres.

METHOD

- Place a blank piece of paper onto the tread pattern of several tyres.
- Shade over the paper to obtain an impression of the tread pattern.
- Record the vehicle type from which the tread pattern was obtained.
- Copy the pattern into a table of results.

RESULTS

vehicle	model	tread pattern

CONCLUSION

1. Does the tread pattern relate to the use to which the vehicle is put? Explain your answer: .....

.....

.....

.....

2. Explain why the tyres on racing cars have no tread:.....

.....

.....

.....

3. Under what sort of conditions would the racing cars change their slick tyres to a tread pattern? .....

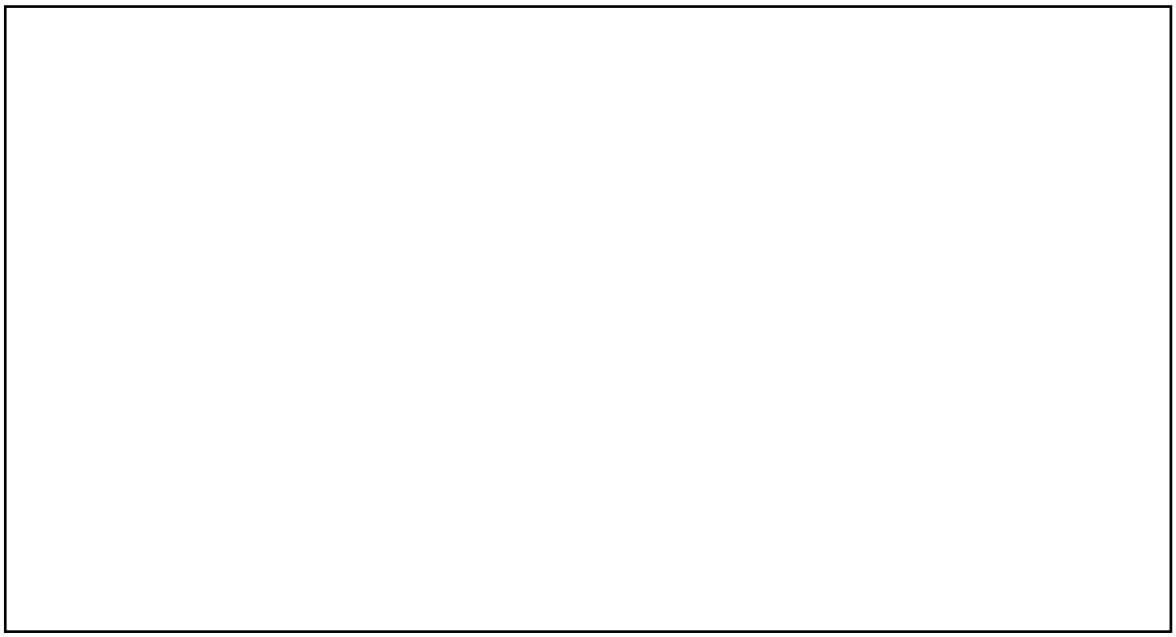
.....

.....

.....

4. Design your own tread pattern, which would be suitable for:

a fairly large truck designed to spend much of its working life in the bush



“Heavy lug type tyres typically fitted to bush fire vehicles affords considerably reduced traction on wet concrete and bitumen surfaces.”

“After a long dry spell, initial falls of rain and the accumulation of dust and oil can make conditions particularly hazardous.”

a 4WD that spends part of its life on the road and part of its life in the bush

FRICTION IN HOSES

When water is propelled through a pipe or a hose, friction is caused by the particles of water rubbing against each other and the walls of the pipe or hose.

The factors affecting friction loss in water hoses are:

1. Length

Loss in water pressure is directly proportional to the length of the hose. This means that if the length of the hose is doubled, the pressure is halved.

Design an experiment to test this. Use a garden hose and devise a method to determine pressure. Communicate to your teacher how you have designed this experiment. You may even like to test your design by undertaking the experiment.

2. Internal surface

Loss of water pressure is directly proportional to the roughness of the internal surface of the hose. A lined hose would have ..... friction than an unlined hose.

3. Diameter

The capacity of a hose depends upon the square of the diameter.

If the diameter of a hose is doubled the hose should deliver ..... as much water.

If the diameter of a hose is halved it should deliver ..... as much water.

Design your own experiment to test this .

communication

SYLLABUS CORE CONTENT AREA COVERED BY THESE EXERCISES INCLUDE:

4.24.2 * co-ordinate other systems

(i) identify particular organs and cells in the human body which detect stimuli including heat light and sound and describe the responses to these stimuli

HAVE YOU GOT ANY SENSE?

When we interact with our environment we rely upon our five major senses to transmit and receive information.

These five major senses are:

1 ..... 2 ..... 3 .....

4 ..... 5 .....

Under what conditions could you be deprived of some of your senses? .....

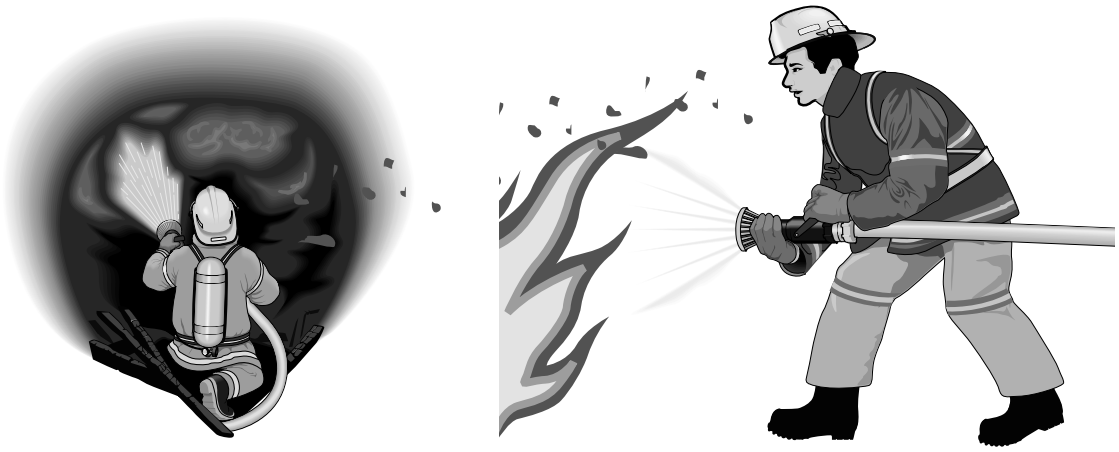
.....

.....

.....

.....

Look at the following illustrations showing some members of the NSW Rural Fire Service in action fighting a fire.



What senses may be increased in this situation and what senses would be decreased?

Senses increased	Senses decreased

Under each of the following headings list the things which we can detect with each of our senses.

see	hear	smell	taste	touch

OUR SENSE OF TOUCH

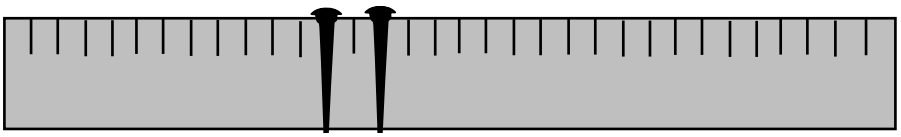
AIM

Are some parts of your body more sensitive to touch than others?

METHOD

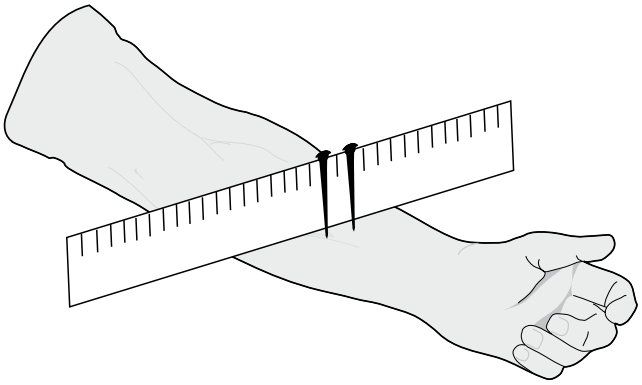
- Equipment
  - two toothpicks or small nails
  - ruler
  - two rubber bands or similar so that the nails or toothpicks can be attached to the ruler
  - blindfold

- Attach the nails or toothpicks to the ruler so that they are about 1.5cm apart.



- Put the blindfold onto your partner and touch the back of their hand with the two points.
- Slowly move the two points together and ask your partner to tell you whether they can feel one or two points.
- Record the distance between the two points when your partner tells you that he or she cannot tell whether it is one point or two.
- Repeat this for different parts of the arm and hand.

RESULTS



CONCLUSION

1 Which area of the skin was most sensitive? .....

2. Which area of the skin was least sensitive? .....

3. If you wanted to find out if something was hot, describe how you would go about doing this?

.....

4. Why must some parts of the skin be more sensitive to touch than others?

.....

5. What sorts of things might affect a person's ability to detect touch?

.....

FEELING THE HEAT

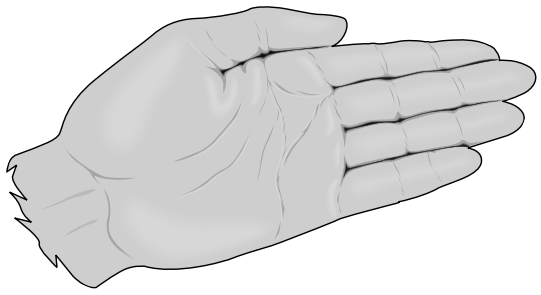
AIM

Are heat receptors located evenly about our hands?

METHOD

- You will need a needle, some warm water, and some icy water.
- Dip the blunt end of the needle into the warm water and touch it onto your hand.
- If you can detect the warm needle, mark that position on the diagram of the hand.
- Repeat this procedure with the cold water.

RESULTS



CONCLUSION

1. Is there any difference between the location of hot and cold receptors on your hand?

.....

2. Where are most of the heat receptors located on your hand?

.....

3. Why do you think that the hot and cold receptors are located in this way?

.....

QUICK OFF THE MARK.

We survive many situations by having an immediate automatic response to a stimulus.

This type of reaction is called a reflex action.

HOW FAST ARE YOUR REFLEXES?

AIM:

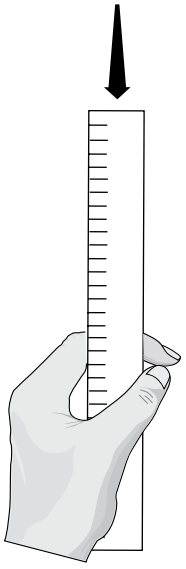
To see if I have the quickest reflexes.

MATERIALS:

A ruler, quick wits and a willing partner.

METHOD

- Your partner will hold the ruler between your thumb and your first finger as shown in the diagram.
- Ensure that your fingers are the same distance apart each time that you do this experiment eg. 5 cm.
- When your partner drops the ruler you must grab it.
- Record how far the ruler falls each time.
- Repeat this three times.
- Undertake some vigorous exercise and repeat the procedure.



RESULTS

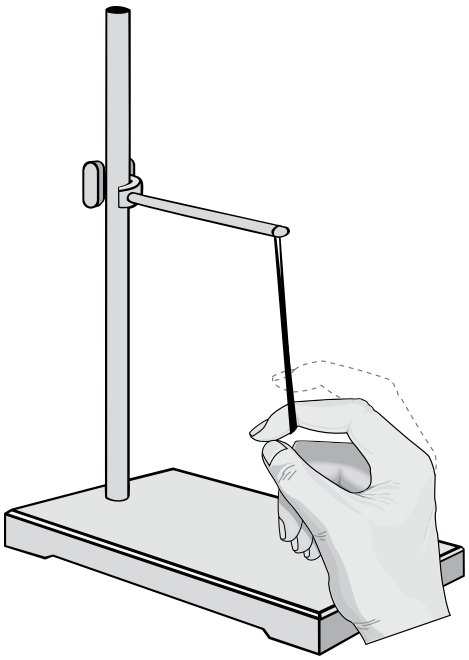
distance ruler fell

	1	2	3	average
before exercise				
after exercise				

CONCLUSION

1. Is there any difference between your reaction times and the reaction times of others in your class?.....
   Why? .....
2. Did participating in the exercise have any significant effect upon your reaction time?
   .....
   .....
   .....
3. Why do you think that it is important for crew leaders to continually monitor the state of alertness of firefighters on a fire front? .....
   .....
   .....
   .....
4. List some other factors, which could affect reaction times of different people, and the reaction times of the same people
   .....
   .....
   .....
   .....

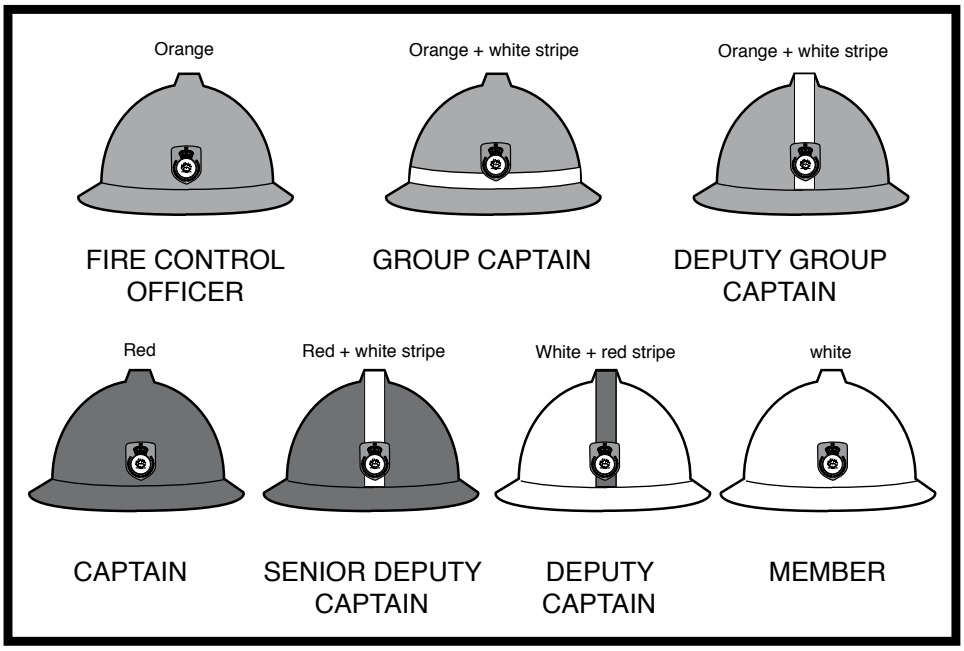
Muscles get tired after strenuous exercise. Undertake the following activity and repeat the reflex action experiment. Place a rubber band over a clamp attached to a retort stand. Exercise your finger by pulling up and down on the rubber band until the finger becomes fatigued. Immediately repeat the previous experiment and compare your results.



When fire crews are expecting to return to the fire ground, attention to rest and recovery will help to ensure they remain effective.

WHAT IS THAT SIGN?

Along with all other animals we are capable of getting the message across by using non-verbal symbols. Look at the following helmets used by Rural Fire Fighters. Each rank has a different type of helmet colour. This is very important in a fire situation so that people can distinguish rank or position is i.e. they serve as a means of identifying people with various levels of responsibility. People can distinguish rank or position from the colour of the helmet.



In the following table describe the helmets worn by various members of the Rural Fire Service. In the second empty column of the table list some other ways in which rank could be displayed. Most organisations (army, navy, air force, police, ambulance, scouts, guides, fire brigades etc) have a system of stripes and symbols on their uniforms to signify rank. These stripes and symbols are usually worn on the sleeve or shoulder.

NSW Rural Fire Service	Helmet worn	Other rank symbols
member **deputy captain** **senior deputy captain** **captain** **group captain** **fire control officer**		

Communication

Members of the Rural Fire Service have a system of signals to indicate to each other the following:

- **WATER ON OR OFF**
- **INCREASE OR DECREASE PRESSURE**
- **MAKE UP EQUIPMENT**

The following diagrams explain how these common hand signals are given.

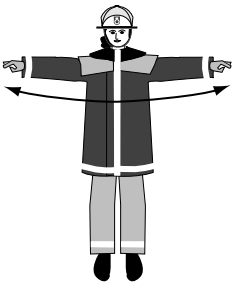
HOSE WORK HAND SIGNALS

WATER ON
Arm raised above the head vertically and dropped to side, fist clenched.

INCREASE PRESSURE
As for "WATER ON". For each display of the signal pump pressure is to be increased by 100kpa.

WATER OFF
One arm extended horizontally from the shoulder and swung across the body.

DECREASE PRESSURE
One arm extended to the side horizontally from the shoulder and dropped to the side. Each display of the signal requires pump pressure to be reduced by 100kpa



MAKE UP EQUIPMENT
Both arms extended to the side horizontally, and held for a few seconds.

In small groups devise a similar set of hand signals that you could use to water the garden.

Practise these signals using a garden hose. List the signals you are going to use in the following table.

Symbol	What it means

Research some signs and symbols used by some different types of animals to communicate with each other

eg. how bees communicate to other bees about the location of a food source.

How baby birds indicate to their parents that they want them to regurgitate their food so that they can be fed.

TREAT WITH CARE!

Every day large quantities of hazardous chemicals are transported by road and rail between the major industrial centres of Australia. Many of these same hazardous substances are transported on every local road in Australia. A vast quantity of them are stored in factories, sheds, warehouses, enclosures and houses.

Compile a list of various substances which are either transported, stored or used in your local area.

Hazardous Substances	Use

Hazardous substances are recognised by using a symbol on a diamond shaped placard.

Observe containers of substances in the science laboratory which have placards attached to them.

Draw the placards for at least 5 substances and briefly describe the substances contained in them.

Placard	Hazardous Substance

Communication

Design a placard for two substances, which you could find in your pantry or under the kitchen sink at home.

(They do not necessarily have to be hazardous substances).

Placard	Hazardous substance

The following signs indicate something to be careful of. Beside each sign write down what you think each sign is saying.

What it means

.....

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REPORTING THE FIRE

WHAT TELEPHONE NUMBER DO YOU CALL IN THE CASE OF AN EMERGENCY?

☐☐☐ **or** __ __ __ __ __ __ __ __ __ __

WHAT NUMBER DO YOU CALL IF YOU ARE REPORTING A BUSH FIRE?

☐☐☐ **or** __ __ __ __ __ __ __ __ __ __

IF YOU HAVE A RURAL FIRE BRIGADE IN YOUR LOCAL AREA, WHO IS THE CAPTAIN OF THAT BRIGADE?

.....

WHAT INFORMATION SHOULD YOU SUPPLY TO THE EMERGENCY NUMBER?

.....

.....

.....

IN THE CASE OF A FIRE CALL-OUT, HOW ARE MEMBERS OF THE LOCAL RURAL FIRE BRIGADE OR OTHER EMERGENCY SERVICES CALLED OUT? .....

.....

HOW HAS MODERN TECHNOLOGY IMPROVED REPORTING AND CALL-OUT PROCEDURES?

.....

.....

.....

COULD MODERN TECHNOLOGY BE DETRIMENTAL TO ACTIVATING CALL-OUT PROCEDURES?

.....

.....

.....

USING TWO-WAY RADIOS

Using pro-words in radio conversation helps to keep the transmission concise; pro-words are standard words which convey a complete message within themselves. The following table lists a selection of commonly used pro-words. Your task is to write in the meaning of each of these pro-words.

Pro-word	Meaning
sitrep	
wilco	
roger	
over	
clear	
say again	
affirmative	
negative	
go ahead	

The **PHONETIC ALPHABET** is a set of internationally recognised words, each of which clearly identifies a specific letter of the alphabet. To use the phonetic alphabet, first say the complete word and then spell it, for example—"HOSE", I spell **H**otel **O**scar **S**ierra **E**cho

Complete the following table, which lists the letter and word used in the phonetic alphabet

Letter	Word
A	.....
B	Bravo
C	.....
D	Delta
E	Echo
F	Foxtrot
G	Golf
H	Hotel
I	India
J	Juliet
K	.....
L	Lima
M	.....

Letter	Word
N	.....
O	Oscar
P	.....
Q	Quebec
R	.....
S	Sierra
T	Tango
U	Uniform
V	.....
W	.....
X	X-ray
Y	.....
Z	.....

energy & heat

SYLLABUS CORE CONTENT AREAS COVERED IN THESE EXERCISES INCLUDE:

4.14. (b) describe expansion and contraction of materials in terms of a simple particle model

4.19.4 (a) describe processes of heat transfer by conduction, convection and radiation

(b) describe how the processes of heat transfer are controlled

WHAT IS FIRE?

Fire is a chemical reaction which reduces complex organic molecules into simpler inorganic compounds.

What is the difference, if any, between a molecule and a compound?

.....

.....

Fire is essentially the opposite of the food-making process, which occurs during photosynthesis. Photosynthesis takes in the energy of the sun to make food and fire releases this energy as heat.

UNSCRAMBLE THE WORDS

For fire to occur the three elements of the fire triangle have to be present. They are:

• XGYNEO .....

• THAE .....

• UFLE .....

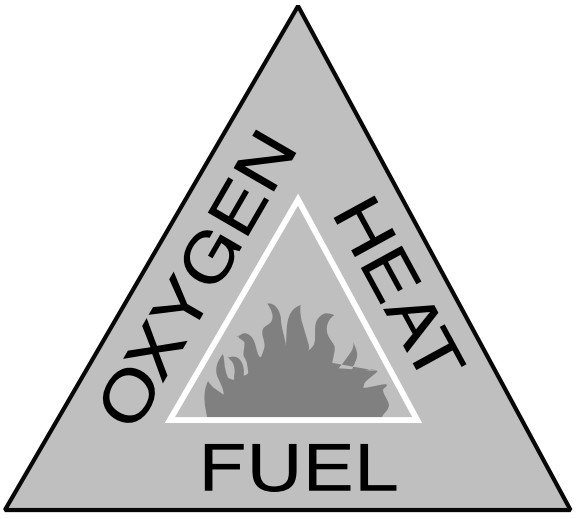
The heat needed to make something burn may come from:

• .....

• .....

• .....

No amount of dry grass or tree litter or any other fuel will burn unless it can be heated to ignition point.



THE FIRE TRIANGLE

Complete the following statements about the fire triangle by choosing the appropriate word from the word list.

- All fires need .....
- Fuel is the stuff that .....
- Fuel may be dry ..... and twigs, or dry .....
- If there is no fuel, there can be no .....
- All fires need .....
- Before fuel can burn, it has to be made very .....
- When fuel gets hot ..... it catches fire. (ie it reaches its ignition point)
- If the fuel is not ..... there can be no fire.
- All fires need .....
- When fuel is heated, it breaks up and ..... with the oxygen in the ..... and bursts into .....

WORD LIST **(Words can only be used once)**

heat enough oxygen near fuel leaves heated air burns grass flame mixes fire hot

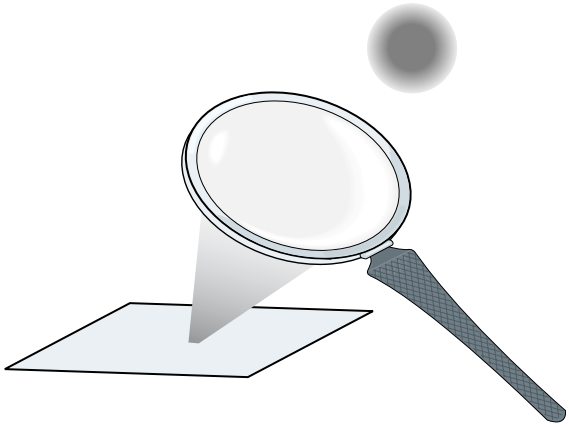
STARTING A FIRE WITH THE SUN

AIM

To convert the solar energy of the sun into the heat energy associated with fire.

METHOD

- Use a magnifying glass to focus the rays of the sun onto a spot on a piece of paper (placing a pen mark on the paper may help it to burn).
- Focus the rays onto a block of wood and burn your name into the wood.
- Pile some dry leaves onto a heatproof mat and focus the sun's rays onto the leaves.
- Compare the time taken for whole leaves to catch fire and the time taken for broken up leaves to catch fire.



RESULTS

- To get things burning with the magnifying glass I had to focus the rays so that .....
- The time taken for the whole leaves to catch alight was .....
- The time taken for the broken-up leaves to catch alight was .....

CONCLUSION

1. Is the heat supplied by the sun greater than the heat produced by the burning objects? .....

   Explain your answer: .....

   .....

   .....

2. Why did breaking the leaves into smaller bits cause a difference to the burning rates? .....

   .....

   .....

3. Explain how bush fires may be started by pieces of glass. .....

   .....

   .....

4. Do you think that this could happen in the bush?.....

   .....

HEAT MAKES THINGS EXPAND

AIM

To discover what makes a bimetallic strip bend.

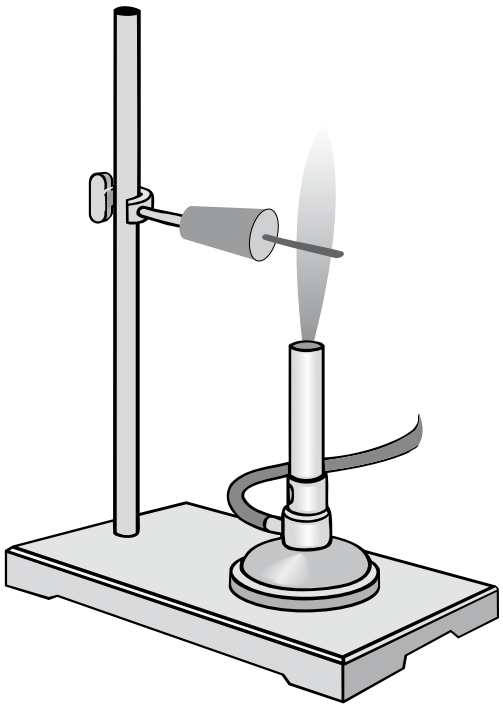
METHOD

Look carefully at the bimetallic strip. Explain why it is called a bimetallic strip. .....

.....

.....

- Label this diagram, then set up the apparatus and perform the experiment.



- Do not overheat the bimetallic strip.
- Heat from one side, turn the strip over and heat again.

RESULTS

1. Describe what happened to the strip when it is heated. .....

.....

.....

2. Describe what happened as the strip cooled down.

.....

.....

3. Describe what happened when the strip was heated from the opposite side.

.....

.....

CONCLUSION

1. What happens to any object when it is heated?

.....

.....

.....

.....

.....

2. Do you think that the two metals expanded at the same rate?

.....

Why? .....

.....

.....

.....

.....

3. List some uses of a bimetallic-metallic strip.

.....

.....

.....

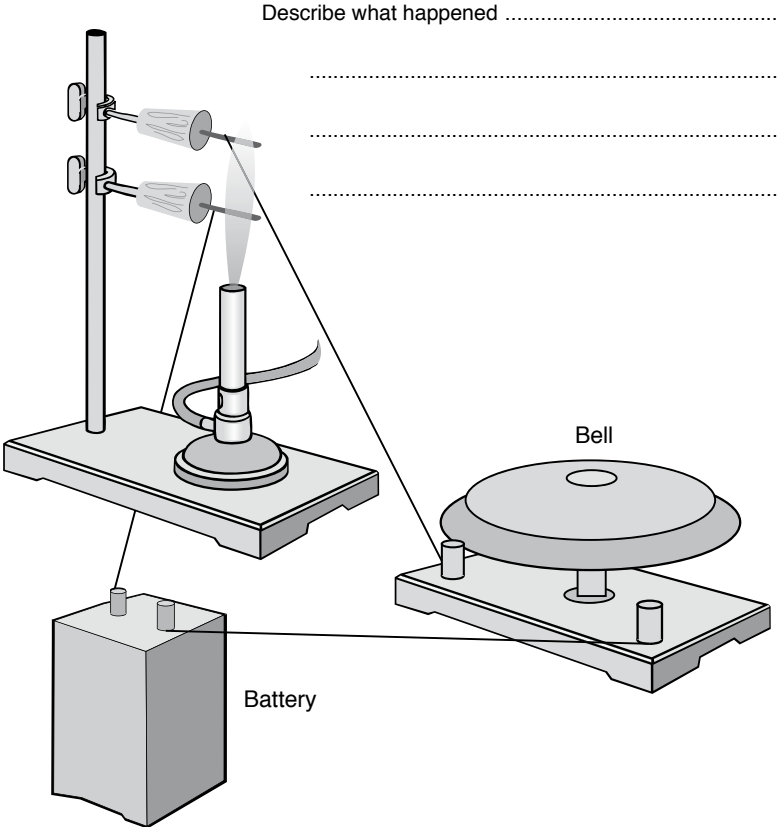
TRY THIS

Describe what happened .....

.....

.....

.....

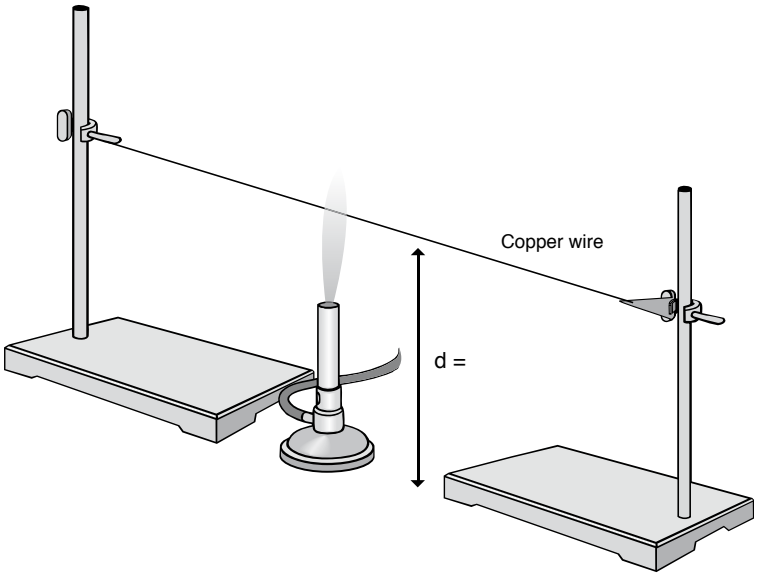


EXPANDING ELECTRIC WIRES

AIM

To demonstrate why it would not be wise to park under electrical wires during a bush fire.

METHOD



• Measure the distance between the desk and the wires before and after heating.

d = ... (before heating) ; d = ... (after heating)

RESULTS

Describe what happened .....

.....

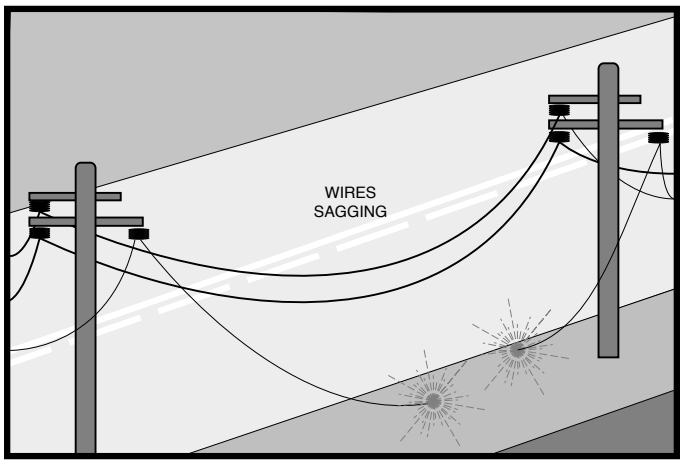
.....

.....

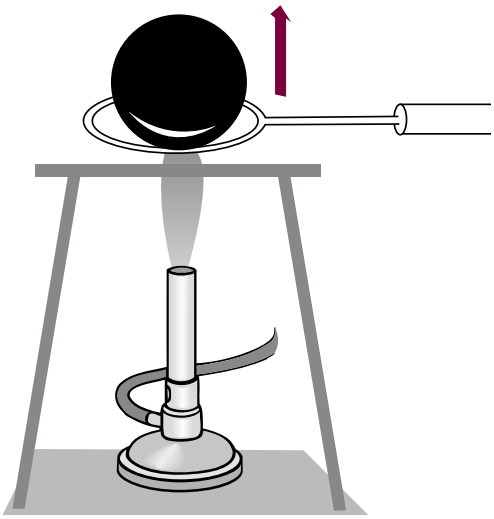
.....

CONCLUSION

From the results obtained in your experiment you should be able to give reasons why fire trucks and other vehicles should not be parked under electrical wires or cables during a bush fire.



EXPANSION OF SOLIDS



AIM

To discover if solids really expand when they are heated.

METHOD

You will need a metal ball and ring set,

a Bunsen burner, a heatproof mat, tripod and gauze

- See if the ball will pass through the ring.
- Heat the ring, and check again to see if the ball will fit through the ring.
- Allow the ring to cool down and check again

RESULTS

	Before heating	After heating	After cooling
Observations			

CONCLUSION

1. The ball was only able to pass through the ring when

.....

.....

2. Some places where we make allowances for EXPANSION and CONTRACTION are:

.....

.....

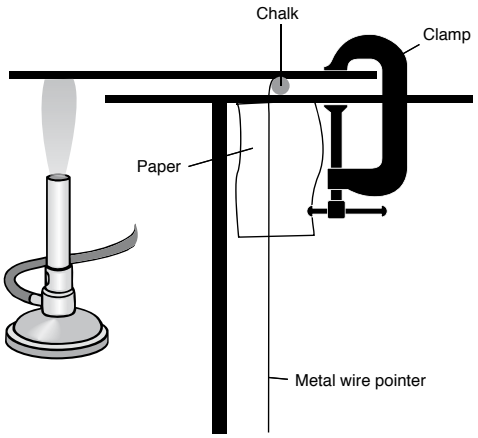
3. Do you think that a pendulum clock would record different times during summer and winter? .....

Why? .....

.....

.....

You could make an “expansionometer” like this:



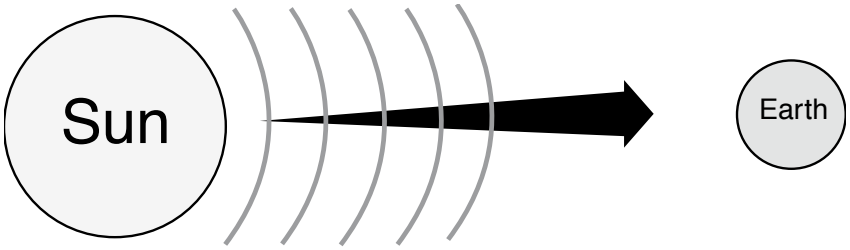
HOW HEAT IS TRANSFERRED

There are three ways in which heat can be transferred:

- Radiation
- Convection
- Conduction

RADIATION

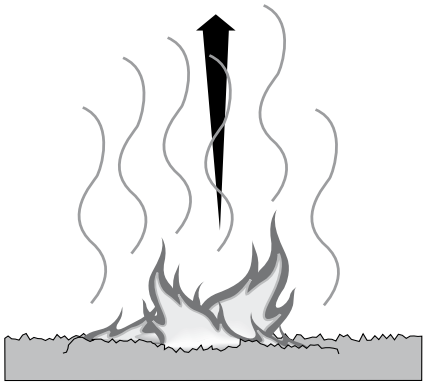
This is the process by which heat energy is transferred from its source to an object ie. it is the direct heat we feel from a fire. Radiant heat is the heat which will directly act upon a fuel immediately before the fire front and bring it to the point where it will burn.



CONVECTION

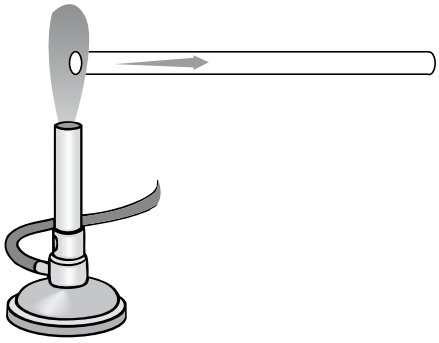
Hot air rises and so carries heat with it. Replacement cooler air is drawn in at the base of the fire. Convection currents at a fire can result in:

- A fire supplying its own oxygen by continually drawing in a supply of fresh air.
- Large fires creating strong winds.
- Hot air rising from a fire carrying pieces of burning fuel, which can then be carried forward into unburnt material. This is called spotting.



CONDUCTION

This form of heat transfer is not a major problem in bush fires. Conduction is the movement of heat along a solid object. Metals are good conductors of heat.

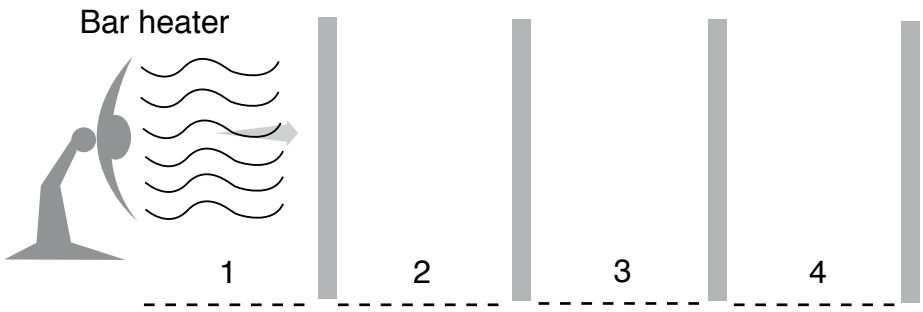


RADIATION

AIM

To measure the rate at which heat travel by radiation drops off as the distance between the source and an object increases.

METHOD



- Switch on the bar heater and measure the temperature change at different distances away from the heater.

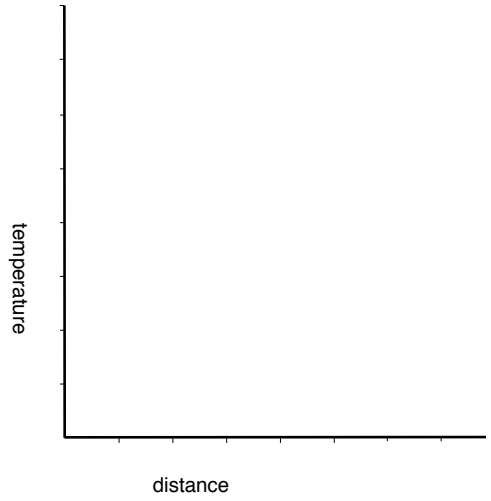
RESULTS You should always show units in the table

Distance from heater (cm)				Temperature (°C)			

CONCLUSION

1. On the following axes draw a graph to show the relationship between temperature and distance away from heat source.

   (Don't forget to include the units ie. °c and cm)



2. Heat travelled from the heater to the thermometer by .....

3. As the distance from the heat source is doubled the temperature drops by ..... times.

A forest fire on a high fire danger day, where there is a heavy fuel loading, gives the equivalent output of 5,200 single bar heaters for every one metre of fire. The more intense the fire, the further away from it firefighters will have to work.

RADIANT HEAT- THE KILLER IN A BUSH FIRE

Every summer people try to protect their homes wearing only dresses, shorts and singlets or even swimmers. They could die without the flames even touching their exposed skin. They don't understand the risks of a bush fire - heat stroke, dehydration, even asphyxiation.

Radiant heat can kill. You need to cover up - dress to protect yourself - take refuge from direct heat.

Distance and shielding protect you from dangerous exposure to radiant heat. The danger is real. Radiant heat from the flame front of a bush fire scorches vegetation well in front of its path. It kills animals caught in the open. People can also die if they do not seek protection. Death is caused by heat stroke, when the body's cooling system fails, leading to heat exhaustion and heart failure.

To protect from radiant heat you need to shield yourself - cover up and take cover.

1. Protect your exposed skin

Firefighters wear protective clothing - so should you. Cover yourself as soon as you become aware of a fire in your area.

2.Take cover inside your house

Radiant heat cannot penetrate through solid objects. This means that your best protection is a well prepared house. Remember that if you flee from your house, you lose the protection against radiant heat.

3. Reduce the risk of dehydration

The high temperatures during a bush fire and the added stress of wearing extra clothing to shield against radiant heat will combine to make you sweat heavily. The fluids you lose must be replaced continuously or you risk dehydration. Keep cool, drink WATER often.

4. If caught on the road

A late evacuation could be a deadly option. If you are caught on the road your car offers the best protection against radiant heat as the fire front passes. DO NOT GET OUT AND RUN. Park the car in as safe a spot as possible, close all doors, vents and windows, cover exposed skin as much as possible with NON SYNTHETIC clothing. To shelter in a car get down as low as possible and cover up with a woollen blanket until the fire front passes. It is still extremely dangerous due to the large amount of plastic used in the construction of newer vehicles. Plan your trip carefully.

Questions

1.What sort of clothes do people mostly wear during hot bush fire prone days? .....

.....

2. What are the three main risks to people during a bush fire? .....

.....

3. What does the radiant heat of a bush fire do to the vegetation and animals caught out in the open in the path of the fire?

.....

4. What causes most human deaths during a bush fire? .....

.....

5. Compile a list of protective clothing that you should wear if you are likely to be involved in a bush fire situation in your area.

.....

6. Why does a house provide good protection against radiant heat? .....

.....

7. What do you think is meant by a well prepared house? .....

.....

8. Why should you drink regularly during bush fires? What are appropriate and inappropriate types of drinks? .....

.....

9. Why should you stay in your car and not run if caught in a bush fire? .....

.....

10. Why should woollen blankets be used to offer protection instead of synthetic blankets? .....

.....

DISCUSSION

Look on the internet at the website AFAC.COM.AU at the article “Guidance for People in Vehicles During Bush Fires”

Discuss in a small group whether or not it is a good idea to shelter in a vehicle or a house and which offers better protection.

A CONVECTION INVESTIGATION

AIM

To ascertain if the air temperature in the science laboratory is uniform throughout the room?

METHOD

This is best performed on a cold winter day when the heaters in the room have been on continuously and the room is feeling nice and hot and stuffy.

• Measure the temperature at various levels in the room.

floor level

50 cm

100 cm

150 cm

200 cm

250cm

300 cm

RESULTS

Position (cm)	Temperature (°c)

CONCLUSION

1. Describe, in words, how the air in the room seems to be layered.

.....

.....

.....

.....

2. Do you think that air particles in the room are stationary or moving? .....

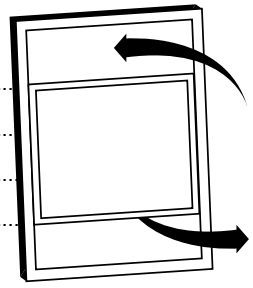
How could you demonstrate this? .....

.....

.....

.....

3. When a window is left open in a room it should be opened so that there is a space above and below the window. Why?



.....

.....

.....

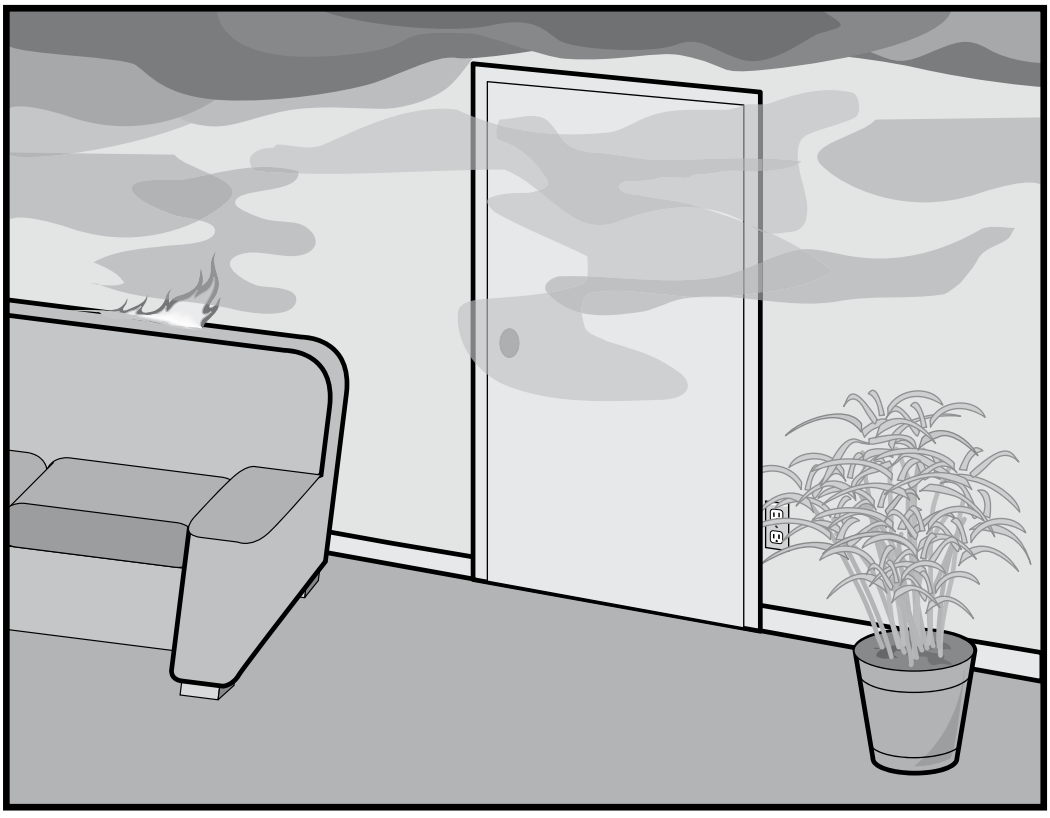
.....

4. Draw a diagram of one wall in the laboratory where a heater is situated. On the diagram use arrows to show how the air might be circulating in the room and use colours and a key to show the different temperature layers in the room.

Convection occurs because:

- air near the heater expands and becomes less dense.
- the less dense air rises in the room and carries heat energy with it.
- at the top of the room the air begins to cool and is displaced by hotter rising air.
- the cooling air descends to the bottom of the room where it is warmed by the heater and so begins to rise again.
- a circulating current of air is produced in the room.

DURING A FIRE IN A HOUSE THE HOT, SMOKE LADEN AIR ACCUMULATES AT THE TOP OF THE ROOM AND THE COOLER, FRESHER AIR IS CLOSE TO THE FLOOR. IF YOU ARE CAUGHT IN A SMOKE FILLED ROOM, WHAT SHOULD YOU DO?



HEAT IN BUSH FIRES

The hottest part of a bush fire is above the flames, where the air gets very hot. Hot air tends to move upwards. This upward movement of hot air is called convection.

When the hot air in a bush fire begins to move upwards, it lifts the smoke from the fire high into the air. Sometimes the smoke lifts well up into the clouds. The rising air can also lift sparks and burning embers into the air.

The bark hanging from tree trunks, and the leaves in the crowns of the trees get heated by the hot rising air. In this way the fire is carried into the tops of the trees and burns fiercely.

If the wind is blowing, burning embers lifted up by currents of hot rising air, can be blown a long way ahead of the fire. If they fall into unburnt fuel, they start new “spot” fires.

1. What is convection? .....

.....

2. How does convection cause crown fires? .....

.....

.....

3. When convection and wind come together, they cause problems. Why?

.....

.....

4. How can convection be very useful at home? .....

.....

.....

5. How can convection be wasteful at home? .....

.....

.....

6. What are burning embers? What do they cause? .....

.....

.....

CONDUCTING THE HEAT

If you have stirred hot tea with a metal teaspoon, you will probably have noticed how the handle of the spoon is warmed by the tea. Heat travels up the handle of the spoon and can be felt by the fingers holding it.
This action of heat travelling through an object is called “conduction”.

Metals are good conductors of heat. Silver is a better conductor than iron. A silver teaspoon will heat more quickly and become much hotter than an iron spoon.

Bush fire fuels are not good conductors. But, when a bush fire is over, burning logs and stumps have to be put out properly. Conducted heat can keep them burning for days.

A smouldering log can start another bush fire days, or even weeks, later.

1. How is heat conducted from one place to another? .....

.....

2. When does conducted heat become important to fire fighters? .....

.....

3. How important is conducted heat at home? .....

.....

4. The work that goes on after a bush fire is called “mopping up”. Explain why mopping up needs to be done properly. .....

.....

5. What is the chemical symbol for silver ....., and iron .....?

6. Meals served on a tin plate go cold a lot quicker than meals served on a crockery plate. Why?

.....

.....

7. Why would aluminium cans cool quicker than glass bottles? .....

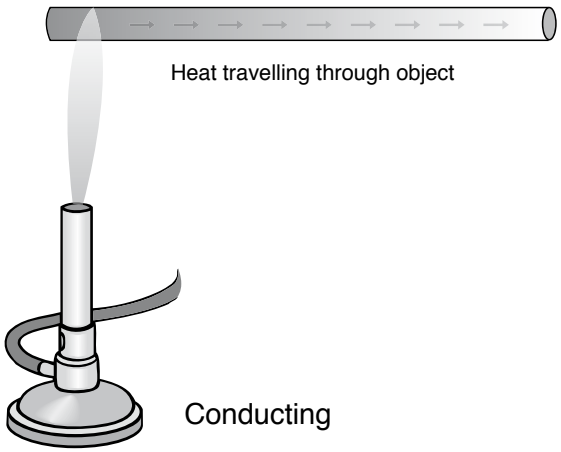
.....

.....

8. How does a drink cooler work?

.....

.....



Conducting

PRODUCED BY NSW RURAL FIRE SERVICE

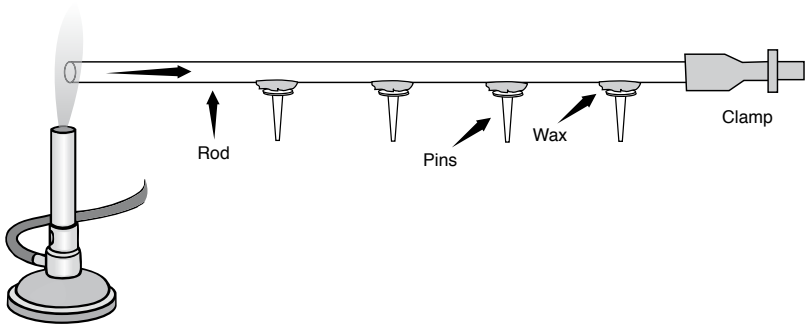
WHICH IS THE BEST CONDUCTOR?

AIM

Which is the better conductor of heat: iron, copper, or aluminium?

METHOD

- Attach some pins or staples to rods of iron, copper and aluminium with paraffin wax.
- Make sure that the pins are the same distance apart (5 cm).
- Heat one end of the metal rod and time how long it takes for the pins to fall off.



RESULTS Time taken for pins to fall off metal rod (s)

	aluminium	iron	copper
1 pin			
2 pins			
3 pins			
4 pins			
5 pins			
6 pins			

CONCLUSION

1. Rank the three metals from the best conductor to the worst conductor.

1. ..... 2. ..... 3. .....

2. Relate the findings of this experiment to the uses to which the metals are put.

metal	uses
aluminium	
iron	
copper	

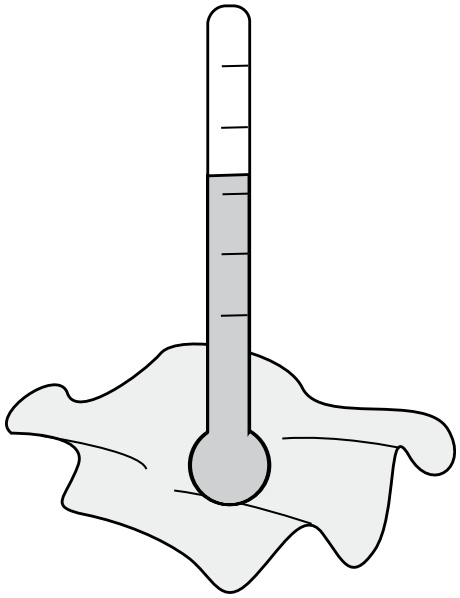
Firefighters feel how hot a door is before they enter a room. Heat would be conducted through the door. Why would it be unwise to grab hold of a metallic doorknob before entering this room?

.....

SPONTANEOUS COMBUSTION

AIM

Can a fire start on its own without any pre-existing fire?



METHOD

- Obtain some old cotton rags or cotton waste.
- Soak the rags with linseed oil.
- Place the rags in a piles on a heat proof mat or bench
- Place a thermometer into the pile of rags.
- Measure the temperature every couple of minutes.
- When you have finished the experiment and have recorded some temperature changes wash out the rags and safely dispose of them.

RESULTS

time (min)	temperature (°c)

CONCLUSION

1. What do you think might happen if the experiment was allowed to go on for a couple of hours?

.....

.....

2. What is Linseed Oil used for?

.....

.....

3. How could house fires start in this way?

.....

.....

4. This type of burning is called “spontaneous combustion”. Can you think of any other circumstances where spontaneous combustion may occur?

.....

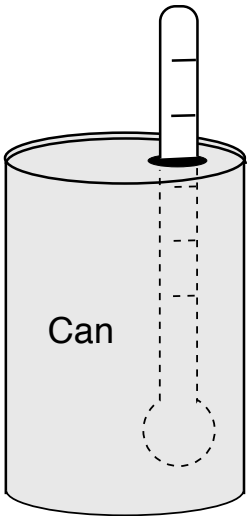
.....

5. Some people believe that humans can undergo spontaneous combustion. Do you think this is correct?

.....

.....

ABSORBING AND REFLECTING



AIM

Do different coloured cans all heat up at the same rate?

METHOD

- Obtain a variety of empty drink cans.
- Try to have a variety of colours.
- Take the cans out into the sun.
- Make sure that all cans are receiving the same amount of sunlight.
- Use a thermometer to record the temperature inside of the cans.
- Measure the air temperature halfway down the inside of the can.

RESULTS

TEMPERATURE

time	can 1 = colour =	can 2 = colour =	can 3 = colour =
1 min 2 min 3 min			

CONCLUSION

1. Which coloured cans heated up the most? .....
2. What coloured cars would heat up the most on a hot day? .....
3. What coloured clothing would be the most suitable to wear on a hot day? .....

Dark coloured objects ABSORB heat, whereas light coloured objects tend to REFLECT heat. The Australian test cricket team often wear white or light coloured clothing. These colours reflect radiant heat and so keep the players cooler.

electricity

SYLLABUS CORE CONTENT AREAS COVERED IN THESE EXERCISES INCLUDE:

4.20.2 (a) describe ways in which objects acquire electrostatic charge

(b) discuss everyday situations where electrostatic forces can be observed

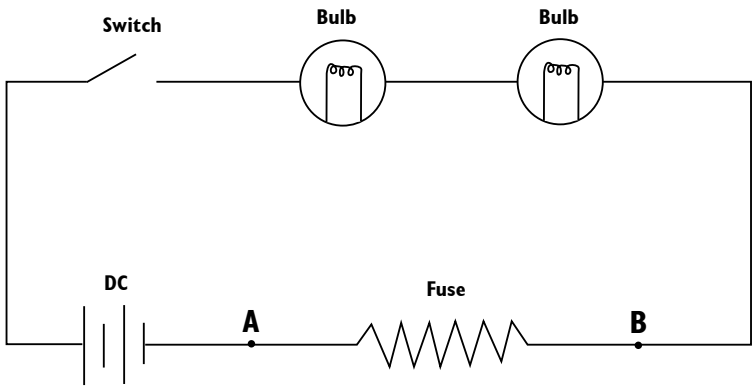
FUSES AND CIRCUITS

AIM

The aim of this experiment is to construct an electrical circuit into which has been placed a "fuse" so that the importance of fuses in electrical circuits can be recognised.

METHOD

- construct the electrical circuit as shown in the following diagram.



- Slowly increase the voltage to the maximum. Observe the effect on the brightness of the bulb and the fuse wire.
- Shorten the fuse wire and repeat the procedure.
- Remove one bulb and repeat the procedure.
- Short circuit the circuit by making a connection between A and B.

RESULTS

what I did	observation
2 volts	
4 volts	
6 volts	
8 volts	
10 volts	
12 volts	
shorten the fuse wire	
removed one bulb	
short circuit	

CONCLUSION

1.What makes the fuse wire glow and burn? .....

.....

.....

2. What sort of electrical appliances take advantage of the findings you obtained in this experiment? .....

.....

.....

3. Are these bulbs connected in series or parallel? .....

.....

4. What would be the effect of connecting more bulbs in the same way?.....

.....

.....

5. When the fuse wire burns the circuit is broken. How can this be a useful thing in electrical appliances? .....

.....

.....

6. Draw a fuse from a house or a car.

7. If there was no fuse connected into an electrical circuit, what might happen? .....

.....

.....

8. How could a "short circuit" occur in a fridge? .....

.....

.....

9. What might happen in your house if there was a short circuit in the fridge? .....

.....

.....

10. Some unwise people replace burnt out fuse wire with a thicker wire so that the circuit keeps going.

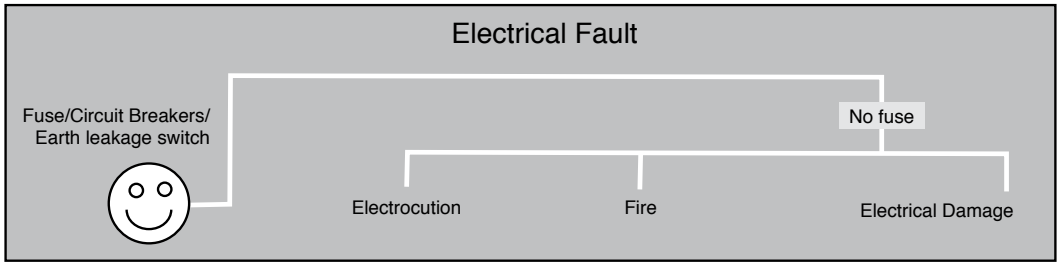
What will be the final result of someone doing this? .....

.....

.....

A fuse protects a circuit from larger than normal flows of electricity. It is the weakest point in the circuit.

Most houses now have circuit breakers or earth leakage switches, which do the same job as the fuse but much more effectively.



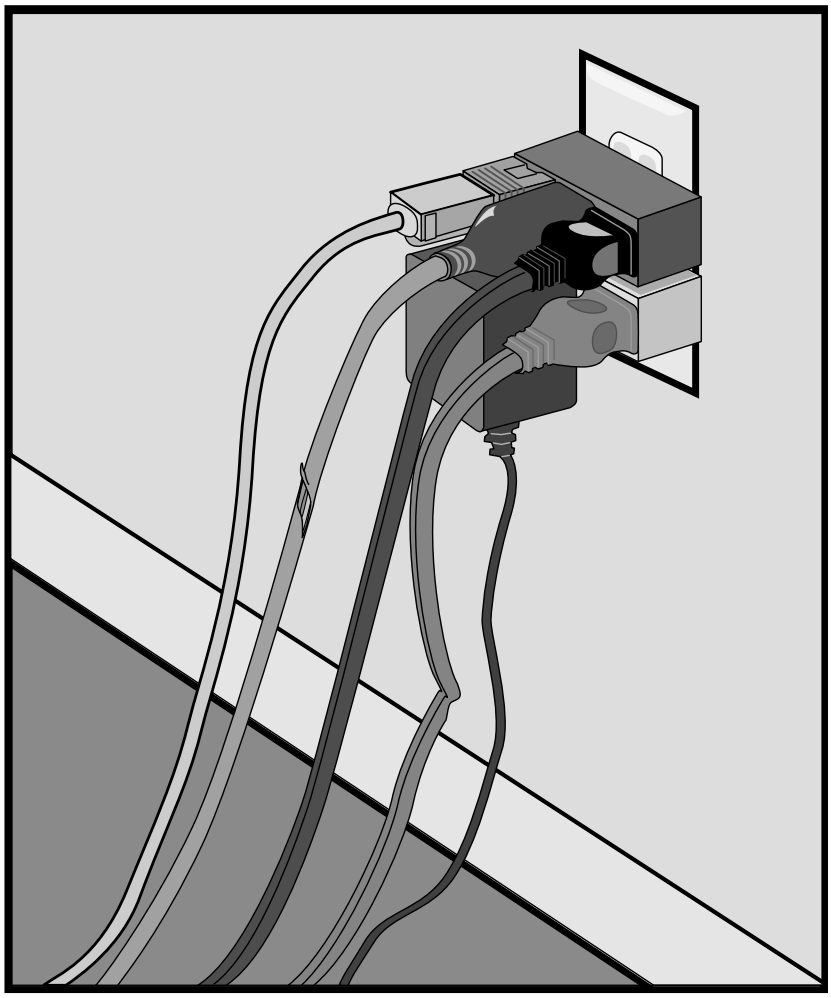
ELECTRICAL FIRE SAFETY CHECKLIST.

Complete the following sentences by inserting words chosen from the word bank below.

1. Do you always have electrical repairs, ... or renovations done by a qualified .....?
2. Are the cords to electrical appliances kept in good .....
   and not placed under ..... or through .....?
3. Do you ensure that power points are not .....?
4. Are ....., stereos, and other electrical equipment operated with enough ..... around
   them to prevent .....?
5. Are all electrical appliances switched off and ..... after use?
6. Are there any clothes or papers lying close to the .....?

WORD BANK

televisions alterations space heater unplugged doorways overloaded overheating electricians condition rugs

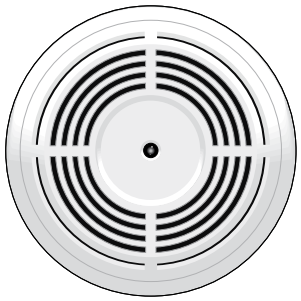


SMOKE ALARMS

Smoke alarms save lives. Installing them at home is an easy and inexpensive precaution against tragedy.
Smoke alarms do not prevent or extinguish fires, but they do provide an early warning that a fire has started, giving you precious extra time to evacuate and call the fire brigade. This is especially important at night when occupants of the house are asleep. Most fatalities from house fires occur at night.

While there are a wide range of smoke alarm units and systems available, a battery operated smoke alarm which you can install yourself is the minimum safety precaution. The NSW Rural Fire Service recommends fitting a smoke alarm outside of all sleeping areas and all exit ways outside of the house. New dwellings must have the smoke alarm connected directly to the dwelling's power supply as well as a battery backup. (It is compulsory to have at least one smoke alarm per home/building Building Legislation commences in NSW on May 1 2006)

There are two kinds of smoke alarms: ionisation or photoelectric. With either operating principle, an alarm is sounded at the first trace of smoke.



Features you should look for in choosing a smoke alarm include:

- They must comply with Australian Standards.
- They should use low cost, low voltage batteries that last at least a year.
- They should have a low battery warning "beep".
- They should have a test button which is easy to locate and use.

Because smoke rises, to detect smoke as early as possible the smoke alarm should be installed on the ceiling or high on the wall. The best placement of smoke alarms depends upon the situation in your individual home.

1. Why should smoke alarms be installed in homes? .....
.....
2. What do smoke alarms do? .....
.....
3. At what times of the day would a smoke alarm be most effective? .....
.....
4. What sort of smoke alarms must be placed in new dwellings? .....
.....
5. Name the two different types of smoke alarms? .....
.....
6. When do smoke alarms sound their alarm? .....
.....
7. What are 4 things you should look for if buying a new smoke alarm? .....
.....
8. Where should smoke alarms be installed? .....
.....
9. If you had to place three smoke alarms in your home, in which parts of the house would you install them? .....
.....

STATIC ELECTRICITY AND LIGHTNING

Friction between non-conducting objects not only makes them hot but it can also move electrons about to give the objects a charge.

If an object has electrons added to it, the object becomes .....charged.

If an object has electrons taken away from it becomes ..... charged.

A balloon is easy to charge by rubbing it on something woollen eg. a jumper.

You can become electrically charged by .....

Place a charged balloon near a fine stream of water flowing out of a tap and observe the effect: .....

.....

.....

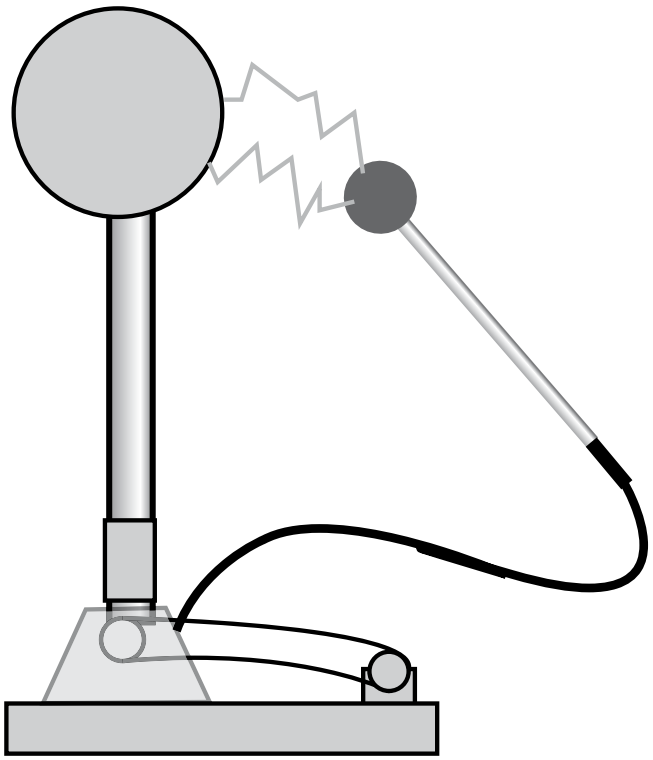
Charge a balloon or your plastic ruler or biro and try to pick up small pieces of paper.

When you become "charged" and you touch something else you see ..... and you get zapped.

LIKE CHARGES ..... UNLIKE CHARGES .....

Attractions and repulsions due to electric charge occur because ELECTRONS want to restore their places so that the objects return to their normal state and have equal numbers of protons and electrons.

If the Van De Graffe generator is "charged" a spark can be seen to jump from an uncharged metal ball to the charged sphere of the generator. Lightning occurs in the same sort of way.



Van De Graffe generator

Electricity

During a thunderstorm air currents cause charges to separate. Positive charges accumulate towards the top of clouds and negative charges accumulate towards the bottom of clouds. The negative charges at the bottom of clouds attract positive charges on the ground. When the difference between the charges is large enough a giant spark forms. Within a fraction of a second a tremendous amount of electricity jumps through the air as a lightning bolt. The bolt may jump from cloud to cloud or from cloud to ground.

Lightning can be the cause of many bush fires especially during a “dry storm” when little or no rain accompanies the storm. What other factors may be associated with dry storms and contribute to the spread of bush fires?

.....

During the bush fires of 1997 there was a succession of dry storms totalling thousands of lightning strikes.

The safest place to stay in a thunderstorm is not under a tall tree. Trees, because of their height, are apt to be struck by lightning and are, therefore, actually dangerous during violent electric storms. The safest places for a person outdoors in a thunderstorm are inside a metal-bodied car or lying flat on the ground in the open.

weather

SYLLABUS CORE CONTENT AREAS COVERED BY THESE EXERCISES INCLUDE:

4.27.1.2 (b) discuss ways in which technologies have been used to predict, monitor and/or counter the effects of catastrophic events

4.29 (d) discuss technological developments that have extended the ability of scientists to collect information about the physical world, living world, matter and earth and space

WEATHER

1. Some reasons that people want to find out about weather are?

.....

.....

2. Some "witty sayings" that we have to describe our weather are:

- It's as dry as .....
- It's as wet as .....
- It's so hot you .....
- It hasn't rained since .....
- You could .....
- It's so cold you .....

3. List some things that animals do, or we complain about, that indicates that a change in the weather is imminent.

what animals do or what we complain about	what it means as far as weather is concerned

4. List some places from where we can obtain weather information. (make sure you include phone, internet and FAX numbers. The telephone directory is a good place to start) .....

.....

.....

5. Unscramble the following words, which are measurable weather elements.

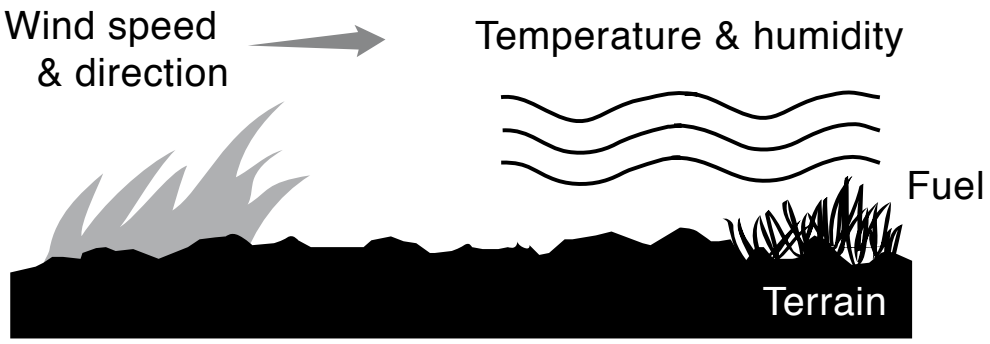
Scrambled word	Weather element
etpetrmearu	
ytdhimui	
ifrnlala	
nidw edsep	
iar uspserer	

Read the following passage and complete the information which follows.

Weather is a vital component of fire behaviour. A typically bad day for fires would be hot, with low humidity, high winds, and a long dry period preceding it. Unstable atmospheric conditions would also increase the risk. The high winds will tilt the flames forward over the unburnt fuel, drying it out and preheating it so that ignition occurs rapidly.

Bush fires do not stand still, their movement depends upon:

- type, condition and arrangement of fuel
- TEMPERATURE AND HUMIDITY
- WIND SPEED AND DIRECTION
- terrain



In the following table explain how you think each of these weather elements affects fire intensity.

HEAT .....

.....

.....

LOW RELATIVE HUMIDITY .....

.....

.....

HIGH WINDS .....

.....

.....

DRY PERIOD .....

.....

.....

TEMPERATURE

All weather is driven by atmospheric energy, originally coming from the ..... . Temperature is a measure of how ..... or ..... something is.

The hottest temperature, which has been recorded in my local area, is .....

The coldest temperature, which has been recorded in my local area, is ..... The hottest time of the year is .....

MEASURING TEMPERATURE

AIM

Does the place from which we obtain temperature measurements affect the readings we obtain?

METHOD

1. Practice making accurate temperature measurements using a laboratory thermometer and a maximum minimum thermometer.
2. List some things you should do to make your measurements accurate.....

   .....

   .....

   .....
3. Record the temperature in various parts of the school environment.

RESULTS

place where I measured	temperature

CONCLUSION

1. If comparisons of temperatures between towns and area locations, are to be made, the measurements must be

   .....

   .....

   .....
2. Find out if your school has a weather station. If so, what features does your weather station have to ensure that accurate measurements are recorded? .....

   .....

   .....

   .....

HUMIDITY

Humidity is a measure of the amount of water vapour present in the air. The humidity of the air depends upon the temperature of the air.

Relative humidity is the amount of water vapour present in the air relative to what the air can hold at that temperature and is expressed as a percentage.

The following information shows how bush fires will behave at different relative humidities.

Relative humidity	Fire behaviour
over 60%	fires will not spread or ignite easily
less than 60%	fire will not spread
dry air 30-40%	fires may spread rapidly or escape easily
very dry 25-30%	spotting commences
20-25%	crown fires may develop
less than 20%	erratic fire behaviour

The average relative humidity in Sydney between 4 January and 9 January 1994 was 18%. What was happening in and around Sydney and in other parts of the state at that time? .....

.....

.....

One word that would describe the fires, which were occurring at that time, would be .....

.....

High relative humidity usually results in dew formation, clouds and maybe storms. We often describe the weather at these times as being hot and ..... How would it feel if the relative humidity were low?

.....

Your laboratory should have a wet/dry bulb thermometer, which is used to measure relative humidity. Locate this thermometer, draw it, and find out how to use it.

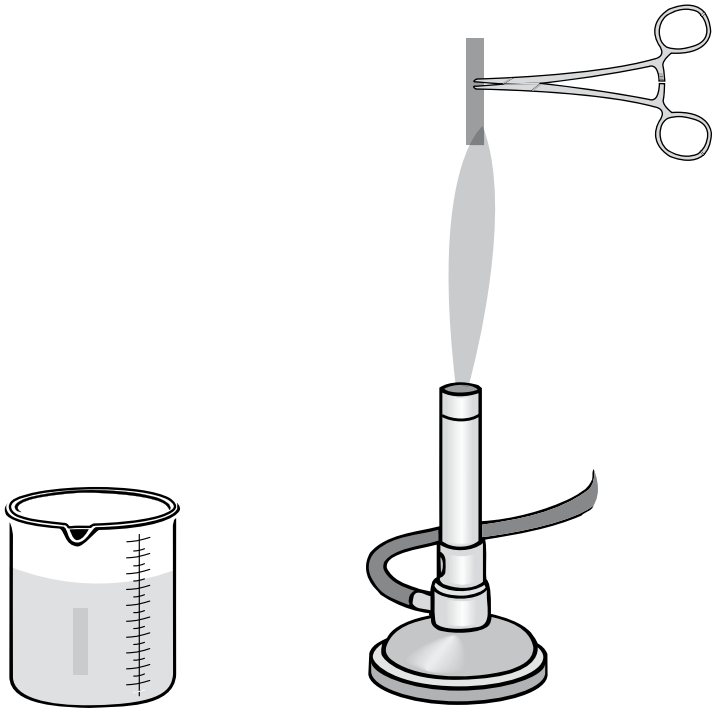
MEASURING HUMIDITY

AIM

To make a simple device, which can measure the water vapour present in the air, and use a wet/dry bulb thermometer to accurately measure relative humidity.

METHOD

- Prepare a solution of cobalt chloride.
- Soak some filter paper in the solution.
- Dry the filter paper above a Bunsen flame (don't let it burn).
- Use a wet/dry bulb thermometer to measure the relative humidity.
- Record any changes in the colour of the cobalt chloride paper.



RESULTS

Relative humidity .....%

Changes to cobalt chloride paper .....

CONCLUSION

1. In the presence of water vapour the cobalt chloride paper is ..... and when it is dry it is .....

2. The relative humidity today was .....%.

3. Where should you go to get accurate measurements on the wet/dry bulb thermometer?

.....

4. What physical process causes the difference between the wet temperature and the dry temperature?

.....

WIND

The unit for wind speed is kilometres per hour and is usually measured over a 5 minute period.

These two diagrams show a Cup Anemometer and a Dwyer Wind Meter which can be used to measure wind speed.

Cup Anemometer

Dwyer Wind Meter

List some things, which might influence wind speed at ground level.

.....

.....

How would wind speed in a forest be different from wind speed measured in the open?.....

.....

.....

.....

Wind is the most important element affecting fire behaviour and is difficult to accurately predict. List some ways in which wind might affect fire. .....

.....

.....

The following table shows the Beaufort Scale for measuring wind speed.

beaufort number	wind speed (km/hr)	specifications	title
0	Less than 1	Smoke rises vertically	Calm
1	1-5	Flags are limp	Light air
2	6-11	Smoke drifts. Flags flutter Wind felt on face. Leaves rustle.	Light breeze
3	12-19	Flags flap, leaves and small twigs in constant motion. Wind extends a light flag, raises dust.	Gentle breeze
4	20-29	Small branches are moved,	Moderate breeze
5	30-39	Small trees sway	Fresh breeze
6	40-49	Large branches move. Wires whistle.	Strong breeze
7	50-61	Flags rise upwards.	Near gale
8	62-74	Whole trees in motion, twigs break off trees.	Gale
9	75-87	Slight structural damage	Strong Gale

On 8 January 1994, wind speed in Sydney was 39 km/h with gusts up to 70 km/h. How would you classify these winds on the Beaufort Scale and what visual affects would they produce?

.....

.....

.....

.....

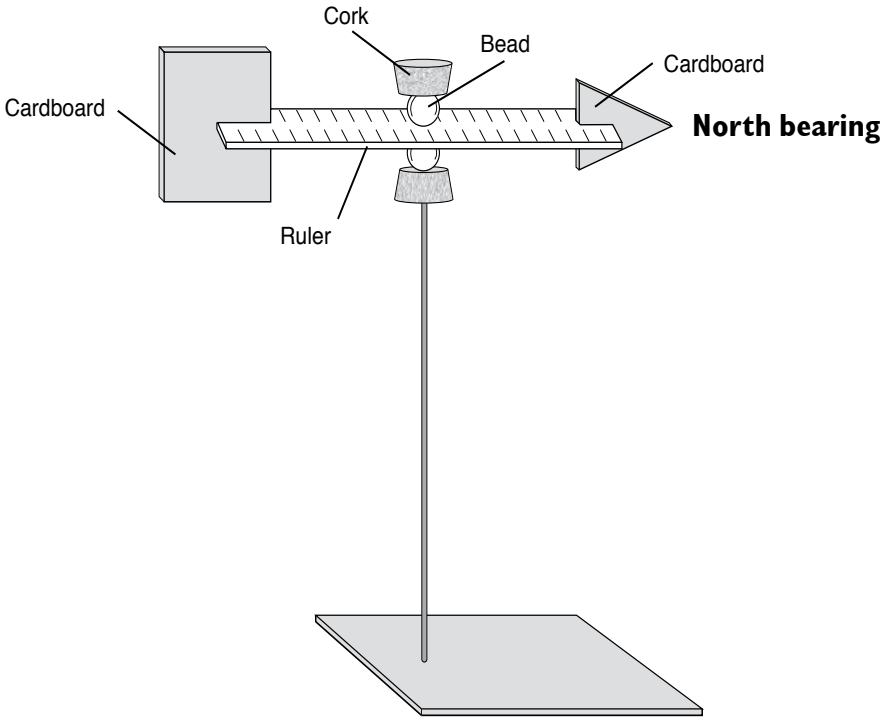
MEASURING WIND

AIM

To make a wind vane to measure wind direction and use the Beaufort Scale to estimate wind speed.

METHOD

- Construct a wind vane similar to the one in the diagram.
- Find an open windy space in the school grounds.
- Rearrange your wind vane so that the north on the base of the "vane" points towards real north.
- Record the wind direction.



RESULTS

Does the arrow point towards the direction from which the wind is coming or the direction in which the wind is going?

.....

.....

Beaufort observations: .....

.....

CONCLUSION

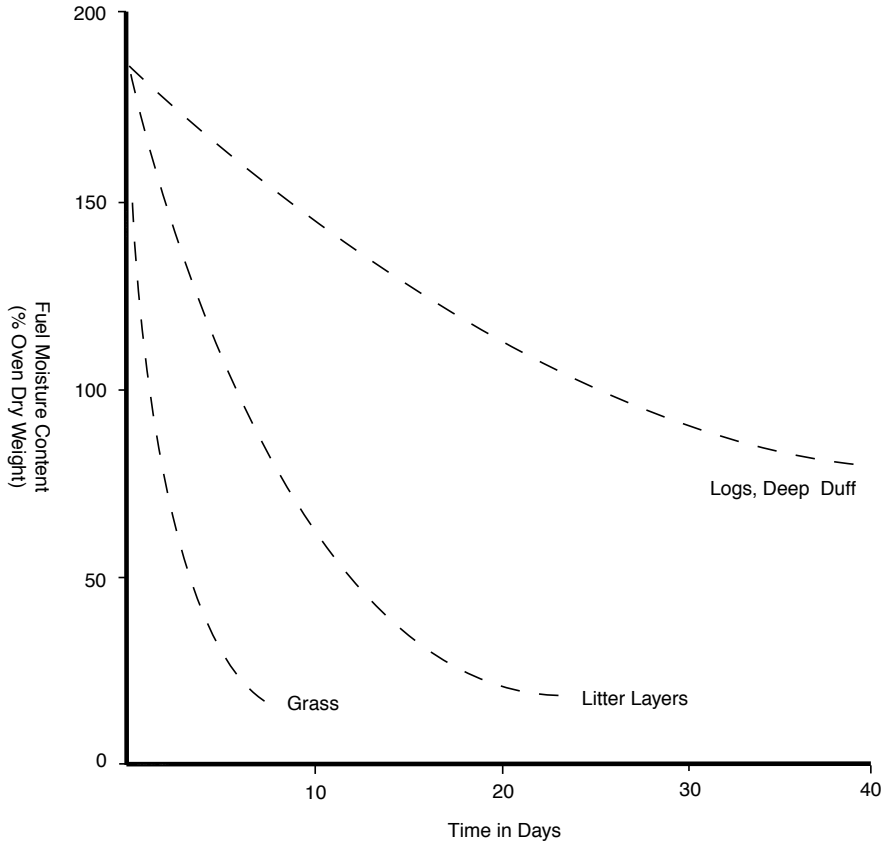
1. The direction of the wind is the direction from which the wind is .....
2. The wind direction on this day was .....
3. My estimate of the wind speed was .....

RAINFALL

1. Collect some rainfall figures for your local area over the last 20 or so years.
2. Calculate the average annual rainfall over this period.
3. Plot this information onto a graph.
4. Look for any patterns or trends.
5. Make a prediction about the rainfall that could occur over the next 12 months.
6. If your predictions are correct tell everyone that you are a competent weather predictor. If your prediction is wrong don't tell anyone.

HOW LONG SINCE IT RAINED?

Suppose that you have had a really dry spell and the grass and fuels in the forest are really dry and constitute a real fire hazard. You then have a storm, which dumps 25 mm of rain in 2 hours, then the rain stops. The following graph shows the relationship between fuel moisture content and time. Use the graph to determine how long it will take for the fuels to reach a critical level again.



Fuel Type	Time	Reasons
grass pine bed logs		

Most serious fires are associated with prolonged dry periods. Under these conditions fuel availability increases markedly.

What happens to leaves and bark during prolonged dry periods?

.....

.....

How could this contribute to bush fires?

.....

.....

Most grasslands will not burn until at least 50% of the grass has been cured.

What do you think “curing” means?

.....

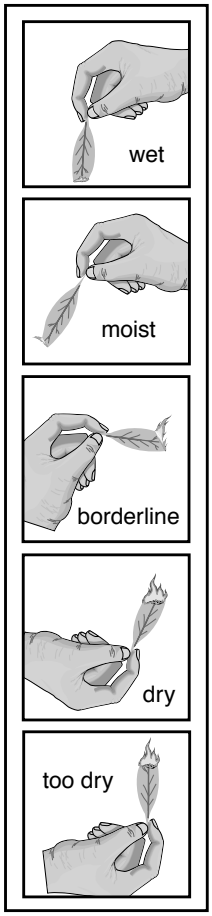
.....

HOW DRY IS THE FUEL?

AIM

To perform a single leaf test to assess the fuel moisture content (FMC) of the leaf.

METHOD



Leaf burns if held straight down or does not burn at all
All fuels too wet if this leaf is in the area to be burnt.
OK if only in wet area not to be burnt.

Leaf burns if angled downwards
Fine fuels from this leaf's position will only burn if on a slope or in the wind.
OK if the leaf was from the bottom of the litter in the burn area, or from a wet area not to be burnt.

Leaf burns if level
Fine fuels from this leaf's position will burn, but very slowly unless helped by wind, slope and fuel continuity.

Leaf can be angled upwards and still burns
Fine fuels from this leaf position are dry enough to burn.
OK if this leaf is from the top of the litter, risky if from the bottom.

Leaf burns if held straight up
All fine fuels are very dry and flammable. Fire will spot if windy.
DON'T BURN

RESULTS

List your observations:

CONCLUSION

1.The fuel moisture content of the fuel was .....

.....

2. Describe other fuels from the area from which you obtained the leaf. .....

.....

3. List some factors which would have contributed to the FMC of the leaf.....

.....

4. Describe a fire which might burn in a fuel such as this. .....

.....

5. Determine how long it may have been since the last rain. .....

WEATHER MAPS

- Lines which join places with equal air pressure on a weather map are called .....
- High atmospheric pressure areas are called ..... and low atmospheric pressure areas are called .....
- High generally means D..... Low generally means H_O.
- Winds circle a LOW in a ..... direction and winds circle a HIGH in an .....direction
- During January 1994, westerly winds moving across NSW were .....and .....
- What was generating these winds at that time? .....
  .....
- Place a symbol in the middle of this system and place arrows onto the map to indicate the wind direction.
- The other feature shown on these weather maps are ..... fronts.
- Describe the weather effects that these fronts were producing. .
- Describe conditions of temperature, humidity and winds which were being experienced at this time.

Weather Conditions - January 1994

For the period 5 January to 9 January, 1994, a deep, low pressure system was located to the south of Tasmania maintaining hot, dry, westerly winds over New South Wales. Such conditions are more typical of late winter or spring. Weak sea breezes near the coast gave way to dry and gusty westerly to north-westerly winds in the afternoons.

Maximum temperatures above 35ºC, relative humidity around 13% and winds gusting to 70 km/h promoted rapid fire spread. Cold fronts passing through New South Wales produced some showers over the Southern Tablelands but brought no relief further north. Gradually, after 9 January, the low moved away. The winds eased and became more humid, from the east to northeast, as is more usual for January.

environment

SYLLABUS CORE CONTENT AREAS COVERED BY THESE EXERCISES INCLUDE:

4.23 (a) recognise that living things are classified according to structural features and that they have patterns of similarity and difference
(b) use keys to identify a range of plants and animals

4.27.1.1 (a) describe some adaptations of living things to factors in their environment including friction, light, gravity, amount of heat and explain how these adaptations assist survival

4.27.1.2 (e) describe the impact of natural catastrophic events including bush fires, floods, cyclones and earthquakes on ecosystems

5.28.1.1 (c) relate some of the reduction in biodiversity to human activities
(d) distinguish between biotic and abiotic features of the local environment

ANTS AND FIRE.

Ants can be regarded as a good species to indicate the health of the environment. Some reasons for this are:

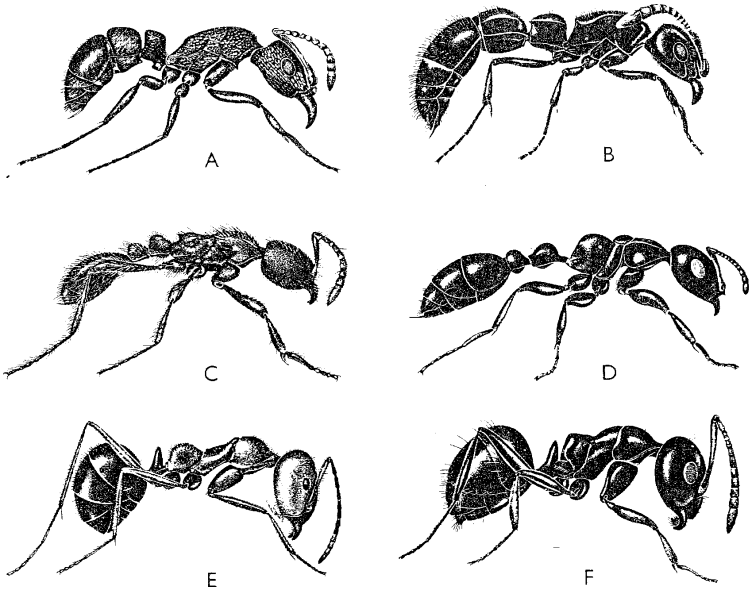
- Ants play an important role in transferring energy and recycling nutrients in forest ecosystems.
- They have many interactions with soil, vegetation and other arthropods.
- The health of populations of other invertebrates is mirrored by populations of ants.
- ANTS CAN BE USED TO MONITOR LAND REHABILITATION AND VEGETATION SUCCESSION FOLLOWING HABITAT DISTURBANCE.

What is meant by each of these following words?

- species .....
- environment .....
- nutrients .....
- recycling .....
- interactions .....
- arthropods .....
- populations .....
- invertebrates .....
- rehabilitation .....
- succession .....

"Periodic fires used for fuel management purposes have few long term effects on most soil and litter invertebrates." Discuss this comment with some of your friends.

The following diagrams are some typical ants which may be found in the Australian environment. In the table under the diagrams compile a profile of ant characteristics.



MY ANT PROFILE

description of ants	what they do

Following a bush fire, ant communities decline in richness and composition. Use of widespread fires for fuel reduction is likely to result in widespread habitat simplification. In the time following a bush fire the plant community begins to re-establish itself. Ant populations are closely related to plant succession.

ant habitat	what fire does to it

In an area which is regularly burnt, do you think it would be characterised by ants with:

Broad environmental tolerance and dietary requirements. OR

Ants with narrow environmental tolerance and specialised dietary requirements.

.....

.....

because .....

.....

DEBATE/DISCUSSION

SHOULD PRESCRIBED HAZARD REDUCTION BURNING CONTINUE TO BE PRACTISED AND BE AN INTEGRAL PART OF AUSTRALIAN PRACTICE ?

Read the following information about ants.

"Ants usually live in more or less permanent nests, excavated in the soil or in the wood or utilising pre-existing cavities in plants or in rocks. The great majority of Australian ants inhabit the ground layers in chambers deep inside the soil or under rocks or other objects. In forests, rotting logs and small fragments of rotting wood are the favoured nest sites. Tree dwelling ants often build silken or plant fibre nests on lower twigs or bark.

Australian ants vary from highly specific predators living on spider eggs, slaters and termites to scavengers and near omnivores. Others depend on seed harvesting for much of their food." (INSECTS OF AUSTRALIA CSIRO)

Decide which ant types would most likely to be found in a regularly burnt forest and say why.

The types which would most likely to be found in a regularly burnt forest would be: .....

.....

.....

.....

Some reasons for this might be:.....

- .....
- .....

.....

.....

WHAT ANT IS THAT?

AIM

To capture some different types of ants and can I recognise them from pictures and reference books?

METHOD

- Ant-catching gear.
    - jar
    - tweezers
    - methylated spirits
    - small paint brush
    - sardines
    - hand lens
    - “stingoes”
- Lay sardine baits where you think different ants might live.
- Wait, and collect ants from the places where you set the baits.
- Place captured ants into the methylated spirits.
- Look for any evidence of fire in the places from where you are collecting the ants.
- Take preserved specimens back to the lab.
- Match your captured ants with the diagrams on the previous pages or from diagrams in other reference books.
- Complete the ant data table.

Catch only different types of ants - not every single ant you see. 3-5 different species should be enough.

RESULTS

ant data table	ant data table
time..... weather..... where..... active/lazy..... colour..... size ..... how many ..... name.....	time..... weather..... where..... active/lazy..... colour..... size ..... how many ..... name.....

ant data table	ant data table
time..... weather..... where..... active/lazy..... colour..... size ..... how many ..... name.....	time..... weather..... where..... active/lazy..... colour..... size ..... how many ..... name.....

ant data table	ant data table
time..... weather..... where..... active/lazy..... colour..... size ..... how many ..... name.....	time..... weather..... where..... active/lazy..... colour..... size ..... how many ..... name.....

CONCLUSION

1. Was there a large variety of ants present? .....

2. Did any of your ant varieties seem more abundant than others? .....

Which ones? .....

3. Would you say that the ants exhibited:

- broad environmental tolerance? .....OR
- narrow environmental tolerance? .....

WHY? .....

.....

4. What evidence, if any, did you find indicating that fires had once burnt in your test area? .....

.....

About how long ago might fires have been in this area? .....

5. How do you think ant abundance and species variety would differ if you examined another area, which had been exposed to different fire regimes in the past few years? .....

.....

.....

PLANTS AND THE AUSTRALIAN ENVIRONMENT

Things, which affect the type and distribution of plants and animals in the Australian environment, are either BIOTIC FACTORS (living) or ABIOTIC (non-living physical measurable).

The abiotic factors which most affect our flora and fauna are:

LLRNIAAF .....

RAEMTRUETPE .....

IEADCTNS .....from the sea

IATDLUTE .....

SSLIO .....

IREF .....

Australian plants and animals have to be able to survive relatively long periods of dry weather and fire has been an integral part of the Australian environment for millions of years. The harsh Australian environment selects out those organisms, which are ..... to survive.

I AM WHAT I AM!

AIM

To design my own plant which would be capable of living in the tough Australian environment.

METHOD

- Discuss and list the rigours of the environment in which your plant will live.
- Compile a data table, which lists the individual plant parts, and the adaptive features your plant will possess.
- Draw and label your plant.

RESULTS

My list of things which characterise the environment.

- .....
- .....
- .....
- .....
- .....
- .....
- .....
- .....

plant part	adaptation
roots stems bark leaves flowers seeds buds	

CONCLUSION

The plant I have designed would be able to survive in the Australian environment because .....

.....

.....

.....

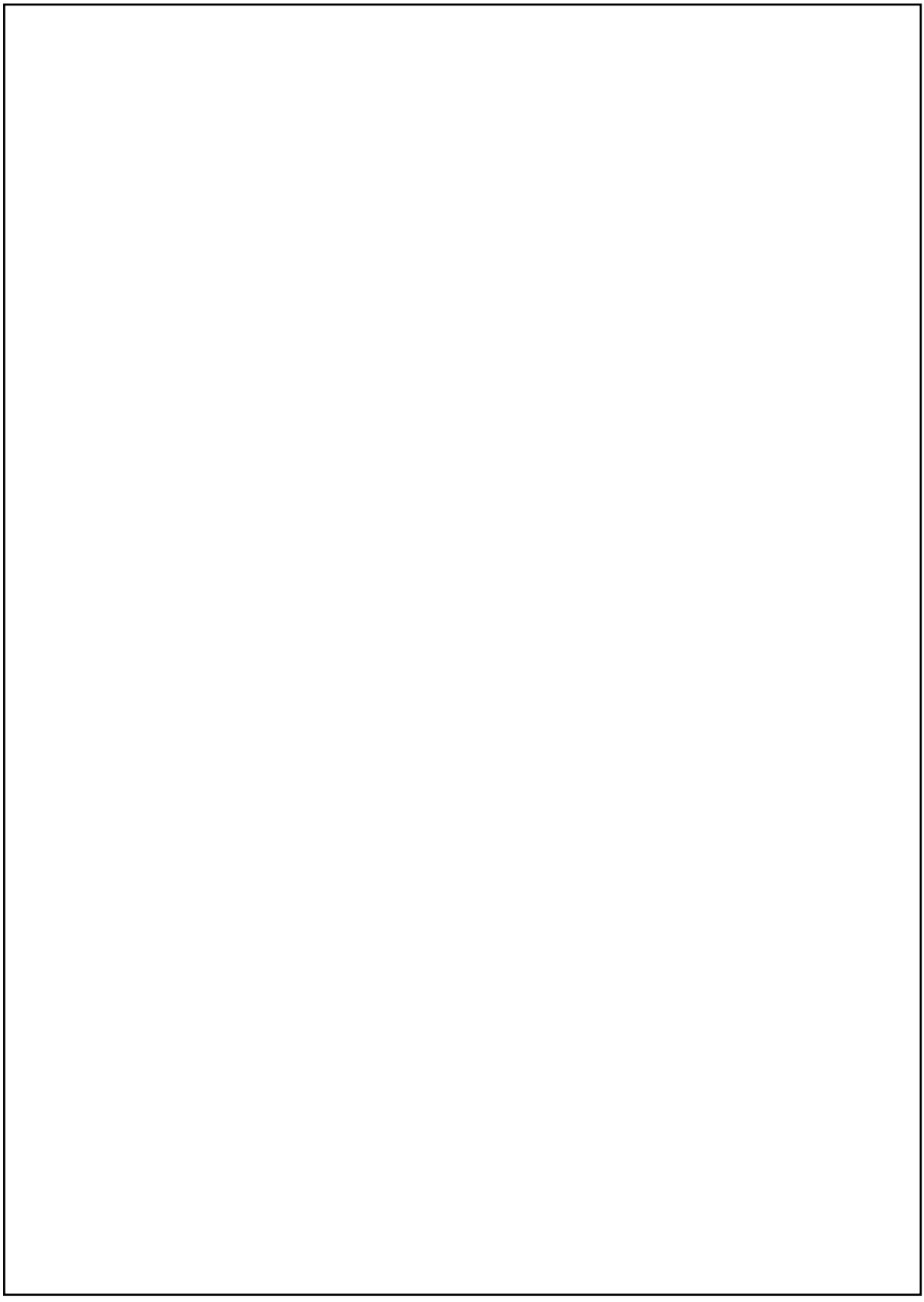
.....

.....

.....

.....

This is what I think a well-adapted plant would look like



FIRE SURVIVAL FEATURES OF PLANTS

Australia's vegetation is well adapted to stresses and extremes in the environment. Drought is the most common factor and others include storms, flood, fire, frost, disease and pests.

A wide range of our trees, shrubs and grasses are well adapted to survive fire (eucalypts, acacias and grass trees are good examples). Fire has played an integral part in the development of Australia's unique flora and fauna.

Survival traits possessed by different plants which survive and recolonise an area following a bush fire include:

- Thick protective bark.
- Dormant buds under the bark.
- Root buds and lignotubers at the base of the trunk.
- Hard seed cases protecting the seed which open up following a hot fire.
- Fire stimulated flowering.
- Hard-shelled seeds stored in the ground.

BARK

Eucalypts have a continuous thick bark in which the trunk and branches are encased. The thick bark insulates the inner layers of the trunk of the tree. The survival of the tree depends upon the depth to which the heat of the fire penetrates. Some barks are less flammable than others.

- The best insulator is stringy bark.
- The poorest insulator is gum bark.

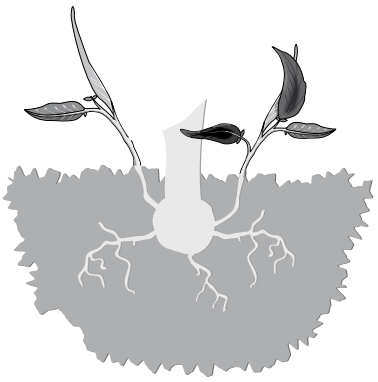
After a tree is burnt, a certain amount of bark is shed, and the tree begins to replace it.

DORMANT BUDS

Thick bark protects the buds buried under the surface in the trunk of the eucalypt tree. Once the canopy of the tree has been killed by fire, shoots (in the form of juvenile leaves) sprout along the main stem and branches of the tree from under the bark. Over a period of years, the tree will once again develop a canopy from this beginning.

LIGNOTUBERS

A lignotuber is a mass of dormant buds buried in a woody swelling, which has developed from the time the tree was a seedling. As the tree grows the lignotuber develops and buries itself further into the soil, from where it will sprout when the tree has been damaged. Lignotubers can hold "food" reserves necessary to regenerate the upper organs of the tree. This is extremely important when all of the leaves of the tree have been scorched. Almost all eucalypts have lignotubers.

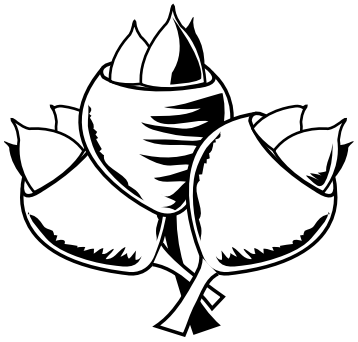


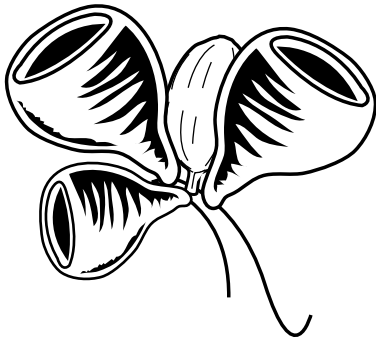
SEEDS

When the plant is destroyed in a hot fire, the seed cases are triggered to open up and release their seed. This as called dehiscence eg. some banksias store their seed on the plant in hard woody follicles or seed cases. The seed case opens up directly after a fire and drops its seed for up to a week on the new seed bed.

Eucalypts produce vast quantities of seed and nearly always have some seed on the tree. The heat from a fire will prompt any seed stored in gumnuts to be released in massive proportions. Severe fires leave an excellent seed bed. Seeds which are shed before the first rains are quickly buried and protected from scavenging ants and dehydration.

Some seeds are extremely hard and need the heat of the fire to crack their hard covering (some seeds survive decades before they germinate).





FIRE STIMULATED FLOWERING

The foliage of grass trees may be burnt and removed but the plant is not usually killed in a fire because the trunk is protected by a sleeve of densely packed persistent leaf bases. The plant produces giant flower spikes 7-10 months after the fire.

1. Write the meanings of these words as they are used in the preceding passage

adapted, flora, fauna, traits, recolonise, dormant, encased, insulates, flammable, canopy, sprout, regenerate, scorched, follicles, scavenging, dehydration, foliage and persistent.

2. List the stresses to which Australian vegetation has adapted.
3. How does the thick bark of the eucalypts protect the plant during a fire?
4. Which eucalypts will be best protected by fire?
5. Describe what happens to a tree once the canopy of the tree has been burnt?
6. What are lignotubers and what is their function?
7. Describe the process of “dehiscence”.
8. What happens to the seed on a tree following a fire?
9. How would a fire provide an excellent seed bed?
10. What happens to a grass tree during and following a fire?

EUCALYPTS -THE SURVIVORS

AIM

To determine if eucalypts are well adapted to the Australian environment.

INTRODUCTION

You are going to collect and examine the parts of several different types of gum tree and relate their features to the ability of the tree to survive our environmental challenges.

METHOD

- Identify the variety of different eucalypts which occur in the school grounds or in the local environment.
- Trace outlines of the leaves from the trees by placing the leaves under a sheet of paper and shading over the outline.
- Compare the structure of the leaves from the gum trees to the structure of leaves of shrubs from a garden.
- Obtain a bark impression of the bark by shading onto a sheet of paper.
- Determine the thickness of the bark by inserting a sharp object into the bark (do not damage the tree).
- Are there any juvenile leaves emerging from buds under the bark?
- Are there any suckers emerging from lignotubers near the base of the tree?
- Collect and draw flowers, buds and seeds from each tree.
- Examine seed capsules.

RESULTS

- Different types of eucalypts found: .....

  .....
- Outline of leaves:

- How leaves compare to other plants: .....

  .....
- Bark impressions:

- Thickness of bark: .....

  .....
- Juvenile leaves:.....

  .....

- Suckers: .....

Drawing of

- Flowers:

- Buds:

- Seeds:

- Seeds /capsules:

CONCLUSION

1. The name eucalypt comes from the Greek words eu and kalyptos which mean “well-covered”.

How well do you think this name describes the eucalypts? .....

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2. Why is it important for the eucalypts to have a thick bark? .....

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3. Eucalypts are said to be sclerophyll in type. What does this mean?.....

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4. Write a statement which links the characteristics of the eucalypts with their suitability to the Australian environment.

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ANIMALS AND FIRE

Fires temporarily decimate invertebrate populations whenever they occur, but post-summer burns are less detrimental than summer or pre-summer burns because life cycles are nearer completion. Pre-summer fires will probably leave significant patches unburnt and these will act as recovery sites.

Invertebrates living in forest litter and on the trunks of trees are able to survive low intensity fires as long as some litter is left unburnt and the invertebrates have areas to seek refuge. Airborne invertebrates are more mobile and have a better chance of surviving fires but many die in the heat and the confusion. Aerial invertebrates recolonise burnt areas more rapidly than litter invertebrates, as they can more readily invade from the surrounding unburnt areas.

The effect of fire on birds is dependent upon their nesting time. Early spring fires may destroy the nests of low nesting species. Late spring fires may not have any effect because the young have already hatched and fledged. Summer and autumn fires have little or no effect because little nesting occurs then. Few deaths of birds, if any, are expected in a low intensity fire but many are killed in high intensity fires. Some species of birds can tolerate frequent fires because the habitat elements they require are not destroyed (eg. lyrebird and yellow robin). Other species cannot tolerate frequent fires and will not live there (eg. brown thornbill). Ground parrots and other species require fires to maintain the habitat they require. The mallee fowl needs long unburnt areas to breed successfully.

Many mammals die or become injured in high-intensity fires as they to try to outrun the fire front, become asphyxiated by smoke or run back through low flames onto hot ground. Many survive by seeking refuge in burrows, tree hollows, gullies or patches that have not burnt. Following the fire, mammals have little cover and are more exposed to predators such as dingoes, foxes, domestic or feral cats and goannas. The populations of these predators may increase. Bats take advantage of exposed insects. As the vegetation recovers, browsing or grazing species such as possums, kangaroos and wallabies recolonise and thrive on the highly nutritious foliage. Some species of mammals are favoured by frequent fire (eg. bandicoot, grey kangaroo) and they rapidly repopulate a burnt site. Species such as ring-tailed possums and bush rats favour less frequent fire because the area takes longer to provide a suitable habitat for them to flourish. Mammals such as the swamp wallaby and some possums need lengthy periods between fires for them to be able to survive. The effect of season on mammals is related to the independence of the young at the time of the fire. Early spring burns carry the greatest risk. The loss of available food, especially during the non-growing season has a marked effect.

1. Find the meanings of these words as they are used in the passage

decimate, invertebrate, detrimental, recovery, litter, refuge, aerial, recolonise, intensity, tolerate, habitat, asphyxiated, exposed, predators, nutritious and independence

2. When are fires likely to have the least impact upon mammals, invertebrates and birds?
3. What could kill airborne invertebrates?
4. What is the major factor influencing the effect of fire on birds?
5. Name the recovery sites that invertebrates can utilise following a bushfire.
6. Why are airborne invertebrates able to quickly recolonise an area after it has been burnt?
7. Find out more information about one of the birds and one of the mammals mentioned in the passage.
8. How do mammals become casualties in a bushfire?
9. Where do many mammals seek refuge?
10. List some mammals whose population numbers might increase following a bushfire.

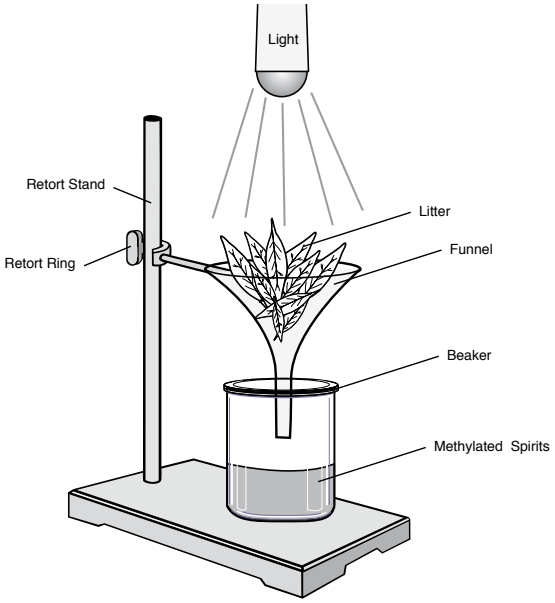
INVERTEBRATES IN THE BUSH

AIM

To capture some invertebrates in some leaf litter and under the bark of some trees.

METHOD

- Obtain samples of moist leaf litter, place them in a plastic bag and return them to the laboratory.
- Set up the apparatus as shown in the following diagram and leave for 24 hours.



- Return to the “bush” with a small paintbrush and some specimen jars filled with methylated spirits.
- Carefully lift the dry bark from a number of trees and collect a sample of invertebrate animals which should be present there.
- Once you have a sample of invertebrates from both the leaf litter and from under the bark you should be able to start identifying them.

RESULTS

Draw and name some of the invertebrate animals you have found:

Some more bugs and grubs:

CONCLUSION

1. Where did you find the largest variety of invertebrates? .....

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2. Comment upon how these animals might be able to survive a bushfire. .....

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A KEY TO SOME INVERTEBRATES THAT MIGHT BE IN THE SOIL

1. (A) Legs (See number 2)

(B) No legs (See number 3)

2. (A) Six or eight legs (See number 4)

(B) More than eight legs (See number 5)

3. (A) Worm-like (See number 6)

(B) Not worm like (See number 7)

4. (A) Six legs (insect) (See number 10)

(B) eight legs **SPIDER**

5. (A) Ten to fourteen legs **SLATER**

(B) More than fourteen legs (See number 8)

6. (A) Body segmented (See number 9)

(B) Body not segmented **ROUNDWORM**

7. (A) Soft body usually with a shell **SNAIL**

(B) No shell **SLUG**

8. (A) One pair of legs per segment **CENTIPEDE**

(B) Two pair of legs per segment **MILLIPEDE**

9. (A) Large anterior sucker for attaching to host **LEECH**

(B) Lives in the soil, no anterior sucker **EARTHWORM**

10. (A) Wings (See number 11)

(B) No wings (See number 12)

11. (A) Hard outer wings **BEETLES**

(B) Outer wings not hard (See number 13)

12. (A) hard bodies with narrow waist **ANTS**

(B) Soft bodies, whitish in colour **TERMITES**

13(A) Front wings leathery at base and membranous **BUGS**

(B) Front wings very small. Cerci on tip of abdomen **EARWIGS**

NATIVE ANIMALS - HOW WILL THEY SURVIVE?

Populations of some animals will decline following extreme fire conditions, although a proportion of individuals survive bush fires by flying out of the area, evading the flames, or taking refuge in burrows and other safe sites.

Unburnt bushland adjoining burnt areas is essential for the re-establishment of populations in affected areas as they begin to rejuvenate. The rejuvenation of wildlife depends partly on rainfall.

Many animals do not suffer as the result of fire, but those that do suffer the most in the post-fire period are the daily feeders (mammals and birds). Reptiles survive longer because they are not reliant upon daily feeding and can shelter underground.

Re-sprouting trees and grass rejuvenate quickly. Animals move back into the area to capitalise on the regrowth.
Any animal that survived the fire, and is mobile and can eat, has a reasonable chance of surviving.
Many animals, eg. invertebrates and insectivorous birds and mammals, actively feed in burnt areas.

1. Explain how a high proportion of individuals may survive a bush fire. .....

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2. Why are unburnt areas adjoining burnt areas important for the survival of animals in a bush fire? .....

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3. Rejuvenation of wildlife depends upon ? .....

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4. What sort of animals have the greatest chance of survival following a bush fire? .....

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5. At what stage do lots of animals move back into the burnt areas? .....

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6. What sorts of animals actively feed in burnt areas? .....

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Community Education Resource Catalogue

Restricted may only be used in certain circumstances | Limited designed for particular application only | Widespread available for general public

Firesafe 1 RFS22
Firesafe 2 RFS23
Firesafe 3 RFS24

Size: A4 Booklet
Distribution: limited
Target Audience: Teachers of Yrs K - 6 Com Ed facilitators

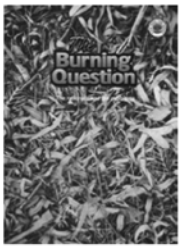
Description:
"Firesafe" offers a complete Science and Technology K – 6 program for teachers. The central theme for the program is fire safety and awareness. The motive for this theme is to reduce the number of preventable fires that occur in our society and to reduce the number of deaths, injuries and damage that result from fires. Firesafe aims to complement the NSWRFS Fireguard for Kids Program which is already operating in many schools. The activities in this workbook can be photocopied without permission provided that the NSW Rural Fire Service is acknowledged as the source.

Firesafe 1,2 & 3 are FREE publications of the NSW Rural Fire Service and are available in class sets.

50 Years of Fire RFS26

Size: A4 Booklet
Distribution: limited
Target Audience: students yrs 9 + 10

Description:
This booklet outlines the event behind a major fire within each decade over the last 50 years. As such the materials provide a valuable tool for the classroom practitioner in the teaching of Geography, Australian History and Creative Writing. To be used as a resource for high school students



The Burning Question RFS91

Size: A4 Booklet
Distribution: limited
Target Audience: students yrs 9 + 10

Description:
This booklet looks at what constituties fuel reduction and why a policy of fuel reduction is needed. To be used as a resource for high school students

A State Ablaze RFS90

Size: A4 Booklet
Distribution: limited
Target Audience: students yrs 9 + 10

Description:
This booklet is designed to place in context the events of December 1993 and January 1994. To be used as a resource for high school students

Fire Science Workbook 1 RFS25
Fire Science Workbook 2 RFS73

Size: A4 Booklet
Distribution: limited
Target Audience: Teachers of Yrs 7 - 10

Description:
Developing a better understanding of the nature and behaviour of fire will enable us to maximise the benefits and minimise the disastrous affects of fire. It is within this context that Fire Science provides learning experiences through which students can acquire scientific knowledge, skills and attitudes within a conceptual framework to facilitate the application of their understanding to everyday life. Fire Science aims towards developing a fire sensible population that will be well informed about fire behaviour, management and safety. This student based activity book relates many of the scientific concepts of fire behaviour and management to the Syllabus Core Content Areas of the NSW Science Syllabus in order to promote fire consciousness into the teaching of science. Science provides a medium in which many of the fire safety concepts introduced in primary school can be continued into the later years at school.

Teachers - Please note:
The activities in this workbook may be photocopied without permission provided that the NSW Rural Fire Service is acknowledged as the source of resources.

Fire Science 1 & 2 are FREE publications of the NSW Rural Fire Service and are available in class sets.

You can find this publication and others
in the NSW Rural Fire Service's education resources on
www.rfs.nsw.gov.au

To order this and other resources call
1800 NSW RFS
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