Ball Games

Contents: Information and problem-solving practical exercises on the science and technology of ball games.

Time: 2 to 4 periods or more, depending on the number of parts and activities attempted.

Intended use: GCSE Physics and Science courses.

Aims:

- To practise measurement skills
- To practise skills in data collection and analysis
- To complement prior work on friction and to introduce ideas on air resistance, turbulence and drag
- To heighten awareness of some of the scientific principles underlying ball games
- To provide an opportunity to practise problem-solving skills
- To link with work in physical education.

Requirements: Students' worksheets No.809. Access to a range of balls, e.g. soccer, netball, hockey, golf, tennis, table tennis, squash. Basic laboratory apparatus, e.g. metre rule, clamp and stand, beaker, balance, tape measure. (See below for further details.)

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This unit is in two parts:

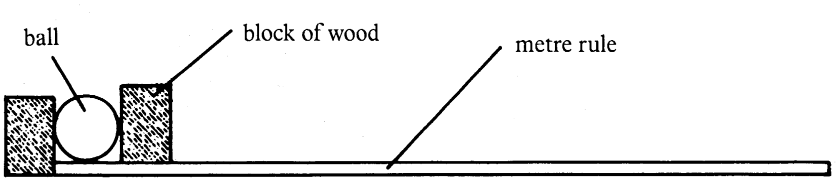
Part 1 Ball types
Part 2 Balls on the move.

Notes on the activities

Activity 1 Looking at different balls

Some students will be able to calculate the volumes of the balls. Others may prefer to measure the volumes by displacement. In addition to the apparatus listed under *Requirements* they may need access to equipment such as calipers, displacement cans, measuring cylinders, lengths of wood.

The diagram shows one method which can be used to determine the diameter of a ball.



Activity 2 Comparing how well different balls can bounce.

This is presented as a problem-solving exercise.

A simple solution is to clamp a metre rule vertically and then to allow balls to bounce from a fixed height of 1m.

Activity 3 What factors affect the flight of a ball?

This is also presented as a problem-solving exercise and is best carried out on the playing field. In order to ensure a fair test, each of the balls should be thrown as far as possible, by the same student, using the same action and the same force. This is probably best done in groups of 3; one throwing, one noting where the ball hits the ground and the third student measuring the distance.

A hockey ball can easily be thrown 50 m but it is difficult to throw a table tennis ball 20 m.

The retardation in flight is proportional to: $\frac{(\text{diameter})^2}{\text{mass}}$

The greater the ratio of (diameter)^2 to mass, the greater will be the retardation force of the air and the more the ball will slow down in flight. In other words, the greater the ratio of mass to (diameter)^2, the less the retardation and the more easily it will 'fly'.

Here are some typical values:

Ball type	*Diameter (cm)*	*Mass (g)*	$\frac{\textit{Mass}}{(\textit{diameter})^2}$
hockey	6.4	160	$\frac{160}{6.4^2} = 3.9\ \text{gcm}^{-2}$
table tennis	3.8	2.4	$\frac{2.4}{3.8^2} = 0.2\ \text{gcm}^{-2}$

Further activities

A Designing a new game. This could be an associated activity with the PE department. It could be run as a competition, perhaps judged by the head of PE. Possible instructions:

- Working in a small group make up a new ball game.
- What size and type of ball will you use - material, surface?
- Will it require a hitting instrument - make a sketch stating what materials it is made from - what the hitting surface is like, particularly if it gives spin to the ball.
- Do the players need to wear any special equipment? How many players? Is it a team game?
- What will you call this game? Can you try it out? Perhaps your PE teacher will give you some help?
- Think about the science involved in your game.

B Comparing the friction of different ball surfaces. Place a ball on a level plank and raise the plank until the ball just rolls. Measure the angle of the plank in each case.

C Investigating the effect of top spin and back spin on a table tennis ball; sketching flight path and direction and extent of bounce. Considering the surfaces of each side of the table-tennis bat.

D Investigating the spin pass and throw of a rugby ball.

E Finding the best spot on a cricket bat to strike the ball, i.e. the centre of percussion.

F Measuring impact times and force of impact between bat and ball.

G Designing a simple machine to project a ball with a constant force in Activity 3 or for dropping a ball and measuring bounce in Activity 2.

H Investigating how angle of club face affects the trajectory of a golf ball. Investigating why golf club faces are ridged.

I Considering which law of physics is obeyed when a ball hits the cushion of a snooker table.

J Investigating the structure of a selection of balls.

K Finding out how balls and tennis rackets are manufactured - use of 'modern' materials, e.g. glass fibre, carbon-graphite.

L Investigating playing surfaces and design of footwear (particularly soles of shoes).

Further resources

Hawkey, R., *Sport Science.* Hodder & Stoughton, 1981.

Page, R.L., *The Physics of Human Movement.* Arnold-Wheaton, Leeds, 1977.

Acknowledgements: Figure 3 supplied by Fort Photography; Figure 6 supplied by Sport & General.

BALL GAMES

Introduction

Some of the ball games we play today were first played hundreds of years ago. A game similar to soccer called 'Tsu Chu' was played in China in 206BC. The goals were about 9 metres high but only 1 metre wide. The leather ball was stuffed with horse hair. For the losers there were no suspensions, fines or yellow cards, simply floggings or even executions depending on the emperor's mood!

An early form of rugby called 'harpastum' was played throughout the world. Ball games can be a source of great enjoyment all through our lives.

Answer questions 1 to 3.

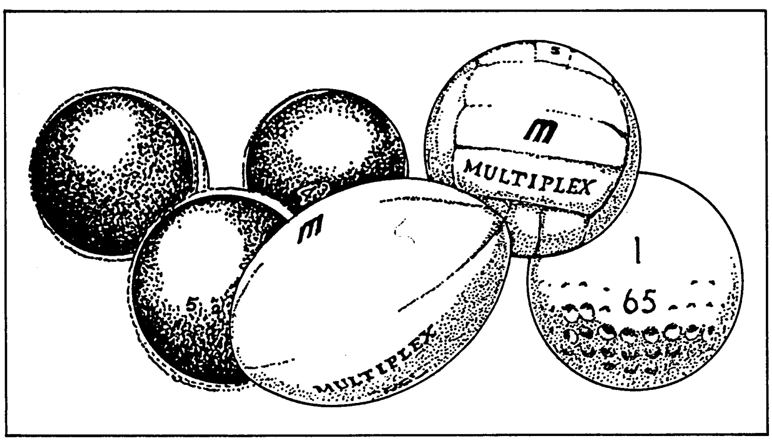


Figure 1

Questions

1 List as many different ball games as you can think of. Can you think of 50?

2 Try sorting the games you have listed. Put them into groups such as: stick and ball games, court games, team games, target ball games.

3 Draw a scale diagram to compare the size of the goal used in Tsu Chu with the size of a modern soccer goal.

Good health

Games can help to keep us fit and to make friends. There are ball games for all seasons and for all ages, for indoors and outdoors.

You need regular exercise throughout your life if you are to keep healthy. Exercise improves your coordination, and your lung capacity. It can also help with weight control. Taking regular exercise makes it less likely that you will have a heart attack.

Answer questions 4 and 5.

Questions

4 (a) Which ball games do you play at school?
(b) Which ball games do you play out of school?
(c) Which of these games do you hope to go on playing after you leave school?

5 (a) How will you take exercise and keep fit when you have left school?
(b) Which games are you likely to want to go on playing all your life?

Science and ball games

There is a good deal of science involved in modern ball games. Examples include the striking of a ball, the flight of a ball through the air or its path along the ground. The amount of bounce a ball has is also an important property in games such as table tennis, squash, tennis or basket ball.

Science and technology also play an important part in the choice of materials used for making bats and balls. Science is also involved in preparing the surfaces that the games are played on.

Part 1 Ball types

Activity 1 Looking at different balls

You will need

- A number of different balls
- Apparatus for making measurements of length and mass

What to do

- Measure the diameter of each ball
- Find the volume of each ball by experiment, or by calculation
- Find the mass of each ball
- Examine the material each ball is made from; describe its surface
- Record your results in a table like the one below.

Ball type	*Diameter (cm)*	*Volume (cm^3)*	*Mass (g)*	*Material and surface type*
soccer	22	5576	420	leather - segments
hockey				
table tennis				

Answer questions 6 to 8.

Questions

6 *In what ways are the balls similar? How do they differ?*

7 *Why do the various ball games need different types of ball?*

8 *How many of the balls are made of natural materials? How many are made of synthetic materials like plastic?*

Part 2 Balls on the move

Bounce

Each ball game requires a ball with a certain amount of bounce. A ball is flattened when it hits the ground or when a bat strikes it.

Balls are **elastic**. They can store **energy** for a short time and then release it as they spring back to their usual shape — so they can bounce.

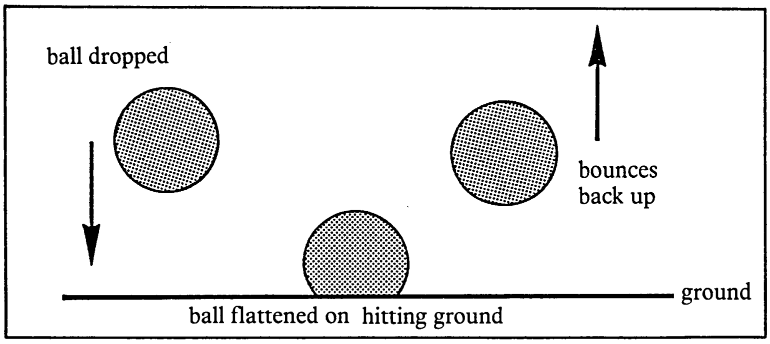


Figure 2

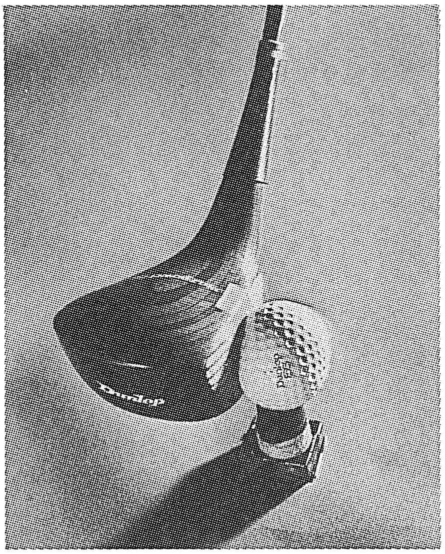


Figure 3 A golf ball at the moment when it is hit by a club

Activity 2 Comparing how well different balls can bounce

What to do

- Design an experiment to measure the amount of bounce of each of the balls you looked at in Activity 1. (How will you make sure that you are carrying out a fair test?)
- Record your results in a table like the one below.

Ball type	*Material*	*Height of bounce (cm)*
squash		
table tennis		

Now answer questions 9 to 11.

Questions

9 *Are the results as you expected?*

10 *Which ball is the most elastic?*

11 *Can you see any connection between the way a game is played and the bounciness of the ball used?*

Moving over a surface — friction

Friction is a force we notice when one surface moves over another. Friction slows down things on the move. When a ball moves over a surface it is slowed down by friction.

Snooker players try to spin the ball when striking it with a cue. Spin reduces skidding. This reduces friction and allows the ball to run freely. The player makes the ball spin by hitting it about 3.5 cm above the table (Figure 4a).

Friction is *least* when a ball is **rolling** or **spinning.**

Friction is *greatest* when a ball is **gliding** or **skidding.**

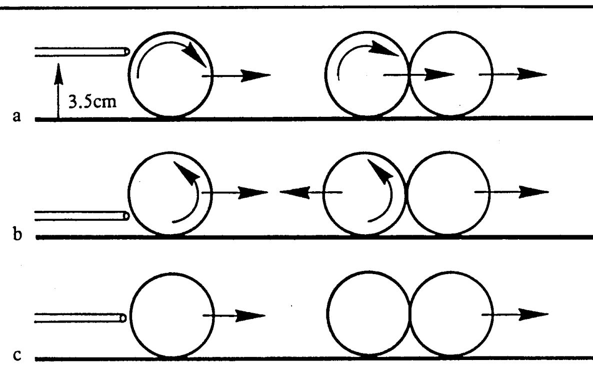


Figure 4

Players also use spin to position the cue ball ready for the next shot. If the cue ball is hit near bottom (see Figure 4b) it gains bottom spin so that it rolls back towards the cue when it hits another ball.

Hitting the cue ball near the top (Figure 4a) gives it top spin. It moves forard after hitting another ball. A cue ball hit in the centre with a 'stunned' action (Figure 4c) skids along and stops on impact.

Bowls and ten-pin bowling players also try to stop their bowls sliding or skidding by giving them top spin. Try it for yourself and you will see the bowl runs along with a smooth, rolling action.

Moving through the air — Air resistance

Air resistance slows down a moving ball so that it does not go as far as it would in a vacuum.

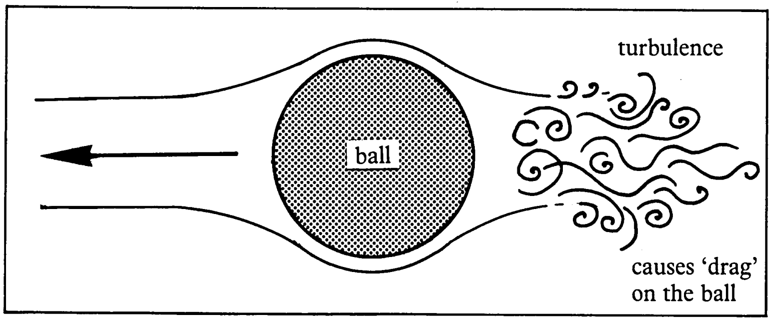


Figure 5

Air has to flow past the ball. The air flow is usually *turbulent* not smooth (Figure 5). The uneven air flow causes *drag.* Drag is a force which slows down the ball. This is similar to the wake behind a ship moving through water.

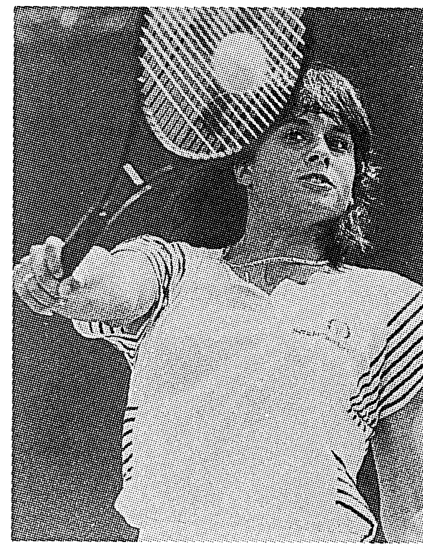


Figure 6 Gabriella Sabatini keeping her eye on the ball at Wimbledon.

Activity 3 What factors affect the flight of a ball?

You will need:

- A range of balls from earlier activity (mass and diameter known)
- Apparatus to measure distance
- A suitable space in which to throw the balls

What to do

- Design an experiment to find out if the flight of a ball is affected by its diameter and mass
- Make sure it is a fair test
- Record your results in a table like the one below.

Ball type	*Diameter (cm)*	*Mass (g)*	*Length of throw*
hockey			
table tennis			

Now answer questions 12 to 14.

Questions

12 Which go further: heavy balls or light balls?

13 Which go further: large balls or small balls?

14 It has been suggested that the value of this formula gives a good idea of how far you can throw a ball:

$$\frac{\text{mass}}{\text{diameter}^2}$$

Do your results agree with this?