

THINKING
ON YOUR
FEET FOOTBALL
AND **PHYSICS** **FOR**
COACHES

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CONTENTS

INTRODUCTION	2
OVERVIEW OF SESSIONS	3
SESSION 1 HOW CAN YOU KICK AND THROW A BALL FURTHER?	6
SESSION 2 TAKING BETTER PENALTIES	8
SESSION 3 HOW CAN YOU ACCELERATE FASTER?	10
SESSION 4 WHAT MAKES A GOOD PASS?	12
SESSION 5 FORCEFUL TACKLING	14
SESSION 6 HOW CAN YOU CONTROL A BALL EFFECTIVELY?	16
SESSION 7 USING YOUR BODY FOR BALANCE AND STABILITY	18
SESSION 8 HOW CAN YOU SPIN AND BEND THE BALL?	20

INTRODUCTION

Thinking on your feet: football and physics is a pack of resources aimed at engaging students with physics by showing its relevance to football. The pack is structured into eight sessions intended to be organised as extra-curricular activities. Each session, like a football match, consists of '45 minutes each way', with the first half being done in the classroom exploring the physics, and the second half on the pitch applying the ideas.

The resources are intended for students aged 11–16: while being designed to be accessible to younger students, they can also provide suitable challenges to stretch higher-attaining pupils. The approach has proved popular and successful with both boys and girls, and it is hoped that the resources have the potential to widen participation in physics by engaging with hard-to-reach students.

ABOUT THIS MANUAL

The Coaching Manual gives brief guidance notes on how to organise the activities on the pitch. Since the activities on the pitch may be run by a non-specialist science teacher (a PE teacher or a coach, for example), the guidance notes include a brief summary of the key physics ideas covered in the classroom session so that the links can be made.

OTHER RESOURCES

Further information can be found in the Teachers' Handbook for *Thinking on your feet: football and physics*, which is accompanied by resources on iop.org/football. In particular, it includes a *Football record sheet* for each session, which is structured to encourage students to briefly record measurements or observations that they make. This is intended to focus their attention on the key physics ideas that they should be exploring on the pitch alongside developing their skills.

HEALTH AND SAFETY

For each activity, safety advice is given to help you assess any risks. In drawing it up, we have assumed an average group of 11–14-year-olds. You may need additional control measures if working with younger pupils, those with behaviour problems or pupils with motor control difficulties.

OVERVIEW OF SESSIONS

SESSION	TITLE	KEY PHYSICS IDEAS	IN THE CLASSROOM STUDENTS SHOULD:	ON THE PITCH STUDENTS SHOULD PRACTISE:
1	How can you kick and throw a ball further?	Projectiles Velocity, distance, angle Experimental design	<p>Make predictions about what angle might give the largest range based on thinking about extreme conditions.</p> <p>Plan an experiment to find the optimum angle to kick or throw a ball.</p> <p>Draw conclusions from their results and evaluate the method used.</p> <p>Relate what they have learned to the real world and why measured values may not match the theoretical value.</p>	<p>Throwing and kicking the ball at different angles to find the optimum angle for increasing the range.</p> <p>Techniques that enable them to kick and throw at this angle.</p> <p>Improving the distance they can manage to throw and kick.</p>
2	Taking better penalties	Accuracy, probability Experimental design	<p>Make predictions about the best place to aim for penalty kicks.</p> <p>Observe videos of penalties and record their observations.</p> <p>Analyse data about the outcomes of penalties.</p> <p>Draw conclusions from data and use these to suggest successful strategies for penalty takers and goalkeepers.</p> <p>Calculate time of travel of a ball from given data.</p>	<p>Improving their penalty kick technique.</p> <p>Disguising which way they will kick the penalty.</p> <p>Choosing a suitable spot in the goal and being able to hit that target.</p>
3	How can you accelerate faster?	Distance, displacement, speed, velocity, acceleration	<p>Use appropriate terminology to describe the motions of objects.</p> <p>Distinguish between speed (or velocity) and acceleration.</p> <p>Investigate and measure the motion of a rolling marble.</p> <p>Design a demonstration to show the difference between acceleration and top speed.</p>	<p>Running on their toes and running with the ball under control.</p> <p>Explosive starts and improving their acceleration.</p> <p>Knowing how to get ahead of an opponent who has a greater acceleration.</p> <p>Beating the offside trap in a free kick.</p>

OVERVIEW OF SESSIONS

SESSION	TITLE	KEY PHYSICS IDEAS	IN THE CLASSROOM STUDENTS SHOULD:	ON THE PITCH STUDENTS SHOULD PRACTISE:
4	What makes a good pass?	Effects of forces Friction and air resistance Force diagrams	Use modeling to demonstrate the relative times it takes for a ball to arrive at a teammate's feet, depending on the type of pass. Identify the forces acting on an object as it moves along the ground or in the air. Draw and label force diagrams using conventions presented. Relate the practical demonstration to the way that footballers pass the ball.	Passing a ball accurately on the ground over greater distances. Establish over what distance each player needs to loft the ball to get the distance.
5	Forceful tackling	Force, impact area, stress	Recognise that certain factors increase the risk of injury from tackling. Design a practical demonstration that shows these effects, qualitatively and quantitatively. Explain how a reduced impact area increases the potential damage done. Relate the practical demonstration to safe and dangerous play.	Taking each other on, trying to get past with the ball. Jockeying an opponent to prevent them getting past with the ball. (With appropriate coaches/teachers only: safe ways of tackling.)
6	How can you control a ball effectively?	Elastic and inelastic collisions, energy Materials, structures	Recognise that different parts of the body can be used to control a moving ball, either to stop it or redirect it. Explain how controlling the ball depends on the part of the body used and how much the ball is actively cushioned. Design a demonstration that shows how much a ball rebounds from different surfaces and structures. Relate the demonstration to the way that footballers control the ball.	Controlling the ball with different parts of the body, including softer parts e.g. chest and thigh. Actively 'cushioning' the ball with different parts of the body. Safely heading the ball.

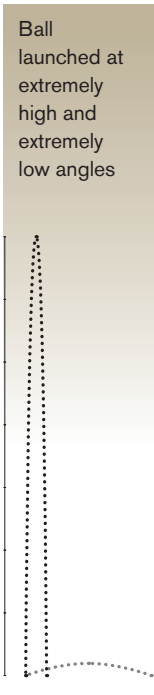
OVERVIEW OF SESSIONS

SESSION	TITLE	KEY PHYSICS IDEAS	IN THE CLASSROOM STUDENTS SHOULD:	ON THE PITCH STUDENTS SHOULD PRACTISE:
7	How can you kick and throw a ball further?	<p>Projectiles</p> <p>Velocity, distance, angle</p> <p>Experimental design</p>	<p>Recognise that the stability of objects is dependent on several factors, including how the mass is distributed within the object.</p> <p>Design a practical demonstration that shows this effect.</p> <p>Identify the differences in effect between an inanimate object and an active person in balancing.</p> <p>Relate the practical demonstration to the way that footballers move in different situations.</p>	<p>Changing direction quickly, with and without the ball.</p> <p>Paying more attention to body movements when practising any skill.</p> <p>Trying to repeat any movement performed with its mirror image.</p>
8	How can you spin and bend the ball?	<p>Accuracy, probability</p> <p>Experimental design</p>	<p>Recognise that spherical or cylindrical objects can be made to spin and this affects their movement through the air.</p> <p>Design a demonstration that shows these effects using video.</p> <p>Explain how spin can be imparted on a spherical or cylindrical object and why it affects the motion.</p> <p>Relate the demonstration to the way that footballers spin and bend the ball in different situations.</p>	<p>Different ways of kicking across the ball to get spin.</p> <p>Exploring sidespin with the inside and outside of the foot.</p> <p>Exploring backspin and topspin and trying to kick it with no spin.</p>

SESSION 1

HOW CAN YOU KICK AND THROW A BALL FURTHER?

Footballers often need to kick or throw a ball as far as possible, for example when clearing the ball from defence or for an attacking throw-in. In addition to how hard it is kicked or thrown, the distance the ball travels depends on its launch angle.



OBJECTIVES

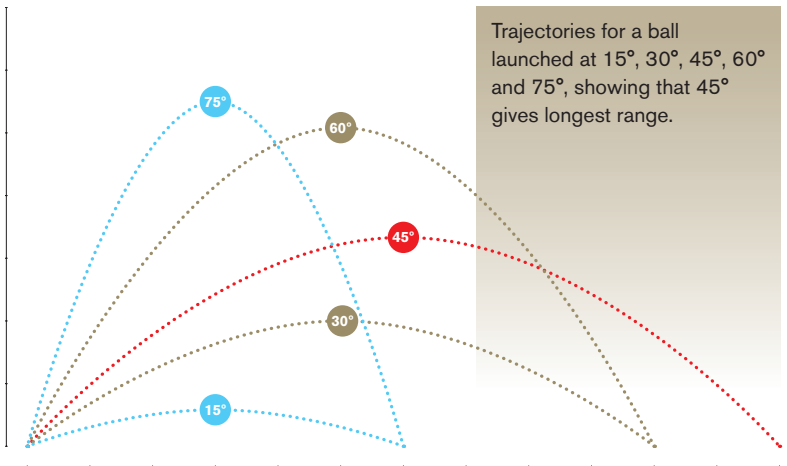
Students should practise:

- Throwing and kicking the ball at different angles to find the optimum angle for increasing the range.
- Techniques that enable them to kick and throw at this angle.
- Improving the distance they can manage a throw and kick.

USEFUL PHYSICS IDEAS

To achieve the longest range, the optimum angle in theory to kick or throw a ball is 45° . In practice it can differ from this because of a number of factors including wind and air resistance.

Keywords: range, optimum angle, air resistance.



RESOURCES

Download a football record sheet for this session from iop.org/football

- Age/capability-appropriate footballs
- Long measuring tape
- Cones to mark distance
- Pens, pencils, clipboards, record sheets

SUGGESTED STRUCTURE AND TIMINGS



Coaching technique for throwing the ball further.



In pairs, practise throwing the ball further and measure the distance.



Coaching technique for kicking the ball further.



In pairs, practise kicking the ball further and measure the distance.



Review what they have learned and set themselves targets.

COACHING POINTS

CAUTION: Before starting, students' warm-ups should include multi-directional movements.

Students repeat the classroom measurements in a real context. A 45° angle can be estimated with one student standing and the other lying down. Range can be measured by partner with cone.

Throwing the ball – start with ball touching the back. Kicking the ball – students should try for consistent speed and relaxed manner. Think about the follow-through.

FURTHER PRACTICE

Students can be encouraged to:

Find a partner and set themselves goals for how far they can kick and throw, or find a wall to kick and throw the ball at.

Practise their distance kicking off the ground (from the hands for goalkeepers), from a dead ball and with the ball moving towards them.

Aim for a 10% improvement per week.

SESSION 2 TAKING BETTER PENALTIES

Penalties can be responsible for determining the outcome of many matches. To some extent, luck is involved. Just as in any game of chance, it is very useful to understand probabilities. Knowing which shots are most likely to score could give a team a critical edge.

OBJECTIVES

Students should practise:

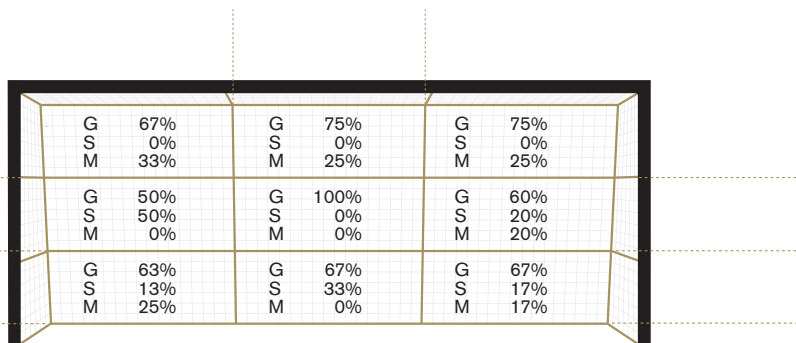
- Improving their penalty kick technique.
- Disguising which way they will kick the penalty.
- Choosing a suitable spot in the goal and being able to hit that target.

USEFUL PHYSICS IDEAS

Good players will be more consistent in getting close to a target: their shots have higher accuracy. When deciding where to aim the ball, a penalty-taker needs to think about the probabilities of missing the goal and of the ball being saved.

Keywords: accuracy, probability.

Probabilities for goal-scoring, saving and missing penalties when aiming at different areas of the goal.



RESOURCES

Download a football record sheet for this session from iop.org/football

- Age/capability-appropriate footballs
- Goals/mini goals
- Cones
- Dice, pens, pencils, clipboards, record sheets.

SUGGESTED STRUCTURE AND TIMINGS



Coaching technique for kicking penalties effectively.



Practise taking penalties, aiming at the five different areas of the goal.



Penalty shootout.

COACHING POINTS

CAUTION: Possible danger for goalkeeper being hit, particularly if using smaller goals and from closer range. Using wider goals marked by cones and taking from 12 yards is safer than small goal posts from shorter distance where the only real option is to blast. Group students according to ability/size.

Demonstrate good technique. Pick a spot, don't look at the goalkeeper, be confident in the run up and hit your penalty firmly.

Students roll a die to determine which area of the goal they should aim at (information on the record sheet).

The record sheet also has information about the penalty shootout. Students enter their results on this sheet.

FURTHER PRACTICE

Students can be encouraged to:

Practise penalties either with a goal or an area marked out with chalk on a wall.

Aim for a target to improve their accuracy.

Research how goalkeepers 'read' a penalty taker to decide which way to dive and how to fool them.

SESSION 3

HOW CAN YOU ACCELERATE FASTER?

Footballers spend a lot of their time running, but not like an athlete running a race. A player will sometimes be moving slowly and sometimes quickly; they will speed up and slow down, and will change direction. Measuring velocity and acceleration can help to track improvements.

OBJECTIVES

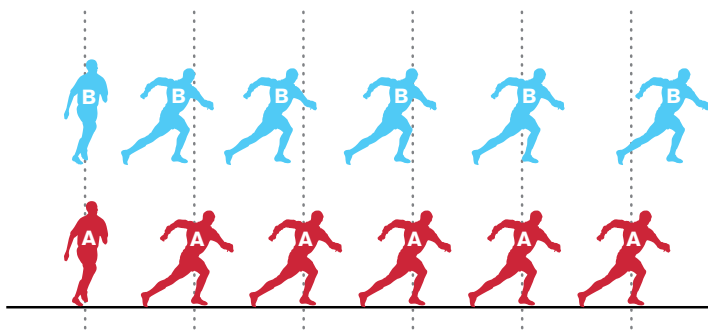
Students should practise:

- Running on their toes and running with the ball under control.
- Explosive starts and improving their acceleration.
- Knowing how to get ahead of an opponent who has a greater acceleration.
- Beating the offside trap in a free kick.

USEFUL PHYSICS IDEAS

Velocity is a measure of how fast something is travelling in a particular direction, and acceleration is a measure of how quickly a velocity changes.

Keywords: velocity (or speed), acceleration.



A has a faster acceleration so is ahead for the first 3 intervals, B continues to accelerate so has a higher top speed and eventually passes A

RESOURCES

Download a football record sheet for this session from iop.org/football.

- Age/capability-appropriate footballs
- Long measuring tape
- Cones
- Stopwatches
- Pens, pencils, clipboards, record sheets.

SUGGESTED STRUCTURE AND TIMINGS



Baseline assessment.
Sprints over five, 10 and 20 metres.



Coaching technique,
running on toes,
keeping low.



Beating an
offside trap.



Review what they have
learned and set
themselves targets.

COACHING POINTS

CAUTION: In the offside trap, there is a possibility of colliding with stationary players if focusing on the moment the ball is kicked. Students should be made aware of this, and spaced so that there is a clear gap and no blocking.

Students should work in pairs, using cones to mark out a five-metre distance initially.

One student sprints while the other measures and records the times, before swapping. They can then measure times over 10 metres and over 20 metres.

The purpose of the offside trap activity is to enable students to time a run so they are not offside. They need to be able to think about how far to throw/kick the ball over the top of the defenders line.

FURTHER PRACTICE

Students can be encouraged to:

Practise timed five, 10 and 20 metre sprints.

Keep a record of distances to track progress.

Practise explosive starts and 'first-step quickness'.

Watch football matches for players timing runs to beat defenders.

SESSION 4 WHAT MAKES A GOOD PASS?

Footballers usually pass on the ground when their teammate is near enough because it is quicker and easier for their teammate to control. They only pass in the air if they have to kick it much further or there is an opposing player in the way.

OBJECTIVES

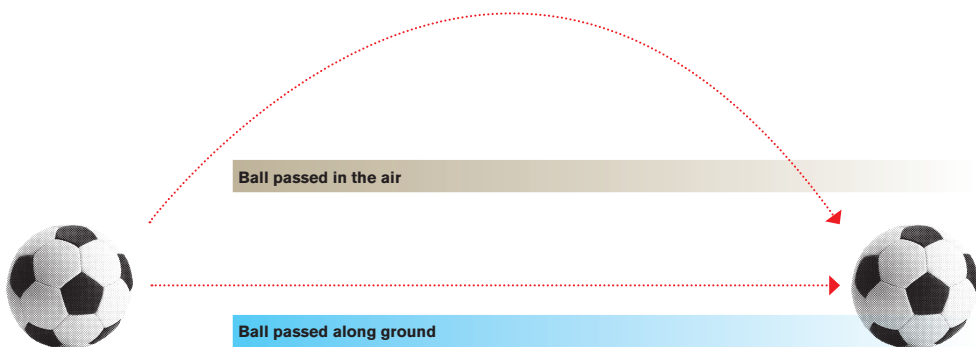
Students should practise:

- Passing a ball accurately on the ground over greater distances.
- Establish over what distance each player needs to loft the ball to get the distance.

USEFUL PHYSICS IDEAS

Over short distances it is quicker to pass the ball along the ground than in the air: it can be kicked with a bigger force along the ground. Over longer distances, it may be easier to pass the ball in the air: the ball can be slowed a lot by friction on the ground which is greater than air resistance.

Keywords: force, friction, air resistance.



RESOURCES

Download a football record sheet for this session from iop.org/football

- Age/capability-appropriate footballs
- Cones for marking distance achieved along the ground
- Pens, pencils, clipboards, record sheets.

SUGGESTED STRUCTURE AND TIMINGS



In pairs, practise passing to each other along the ground with each foot.



Gradually increase distance, marking effective limit for each foot.



Practise accurate lofted passes over greater distances.

COACHING POINTS

CAUTION: With aerial passing, the receiving player could use their hands to avoid getting hit if they cannot control the ball. Space out the groups to reduce the risk of being hit by balls from other groups.

For the surface being used, students can find out their effective limit for a side-foot pass on the ground, and at what distance they need to switch to a lofted pass.

For passing along the ground, students should use the inside of the foot.

For lofted kicks, they can use the 'sweet-spot' in the foot.

FURTHER PRACTICE

Students can be encouraged to:

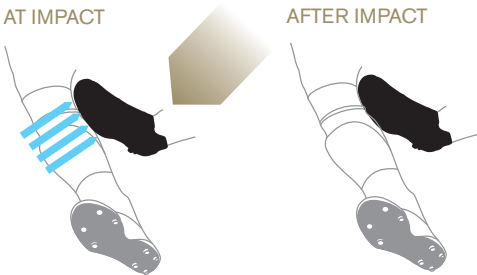
Practise the two types of pass, with each of their feet, with a partner or against a wall. Start with a stationary ball, and then try it with a moving ball and over longer distances.

Try different surfaces and be aware that, if the ground is smooth/hard, the ball will take longer to slow down, and they can pass further along the ground.

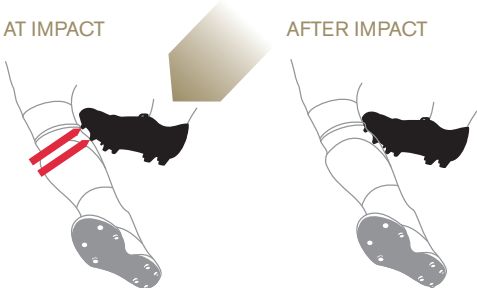
SESSION 5 FORCEFUL TACKLING

Footballers use different ways to tackle opposing players but it is important that they do this safely, without injury to the other player or to themselves. Injuries are most likely to occur when the impact is concentrated over a small area, so this must be avoided.

Side of boot



Bottom of boot (with studs)



OBJECTIVES

Students should practise (with appropriate coaches/teachers only, safe ways of tackling):

- Taking each other on, trying to get past with the ball.
- Jockeying an opponent to prevent them getting past with the ball.

USEFUL PHYSICS IDEAS

Two factors that affect how much damage could be done by a kick on the shin are the force and the contact area. Tackles that involve contact with the studs on a boot are more dangerous because the force is spread over a smaller contact area.

Keywords: force, contact area.

RESOURCES

Download a football record sheet for this session from iop.org/football

- Age/capability-appropriate footballs.
- Cones to mark out one-v-one and two-v-two pitches and goals.

SUGGESTED STRUCTURE AND TIMINGS



Working in pairs, one-v-one matches.



Coaching closing down, jockeying, when/where to tackle.



one-v-one competition matches.



Coaching closing down, jockeying and marking, intercepting.



two-v-two competition matches (or, IF APPROPRIATE, coaching and practising safe stab tackles and block tackles).

COACHING POINTS

CAUTION: It is particularly important here that any form of tackling practice should only be coached by suitably qualified staff working under appropriate conditions, who have carried out a suitable risk assessment.

Players can be encouraged to practise concentrating on the ball not the player during one-v-one matches.

Ask one student to attack, and one student to defend so that they will automatically have to do some tackling.

During two-v-two matches, players also have to be aware of the other opposition player when marking their own and trying to block or intercept passes.

FURTHER PRACTICE

Students can be encouraged to:

Practise one-v-one matches, closing down, jockeying, when/where to tackle.

Practise two-v-two matches, closing down, jockeying and marking, intercepting.

SESSION 6

HOW CAN YOU CONTROL A BALL EFFECTIVELY?

Football often involves trying to control a moving ball: the aim may be to stop it or to redirect it. How the ball is controlled depends on which part of the body is used, such as the chest or head, and how much the ball is actively 'cushioned' by the player.

OBJECTIVES

Students should practise:

- Controlling the ball with different parts of the body, including softer parts e.g. the chest and thigh.
- Actively 'cushioning' the ball with different parts of the body.
- Safely heading the ball.

USEFUL PHYSICS IDEAS

How much a ball bounces off something depends on whether the surface is hard or soft, and on whether it is part of a rigid structure. A ball will bounce most when it hits a hard part of the body that is held rigid, and least off a soft part that is relaxed.

Keywords: hard, soft, rigid, relaxed.



RESOURCES

Download a football record sheet for this session from iop.org/football

- Age/capability-appropriate footballs
- Softer/lighter age appropriate balls for heading
- Pens, pencils, clipboards, record sheets.

SUGGESTED STRUCTURE AND TIMINGS



Individual keepy-uppy practice.



Working in pairs, practise receiving the ball with the feet, thigh, chest and head.



In pairs, practise different ways to head a ball.

COACHING POINTS

CAUTION: When heading the ball, there is a danger that it could hit the nose or face of the student. Students should be alerted to this, and, to start with, practise very gentle headers with a softer ball. Students not used to heading can balance ball on crook of forehead and nose with eyes on the ball.

Keepy-uppy – encourage the use of different parts of the body and both feet.

Spongy contact is needed for controlling/receiving the ball. Practise two things: stopping the ball, and first touch to redirect ball ready for second touch, eg passing ball back to the other player.

Three ways to head a ball: attacking header, defensive header and controlling header.

FURTHER PRACTICE

Students can be encouraged to:

Practise keepy-uppy regularly to develop ball control, and measure their progress.

Find a partner, and practise receiving the ball using feet, thigh, chest and head – stopping the ball and changing direction.

Practise three different ways to head a ball: attacking header, defensive header and controlling header.

SESSION 7

USING YOUR BODY FOR BALANCE AND STABILITY

Footballers use their whole body in order to run, turn, jump, kick, tackle, head or throw as effectively as possible. High performance in any of these areas is a combination of body shape and technique. Balance and stability are concerned with controlling and maintaining the position of the body.

OBJECTIVES

Students should practise:

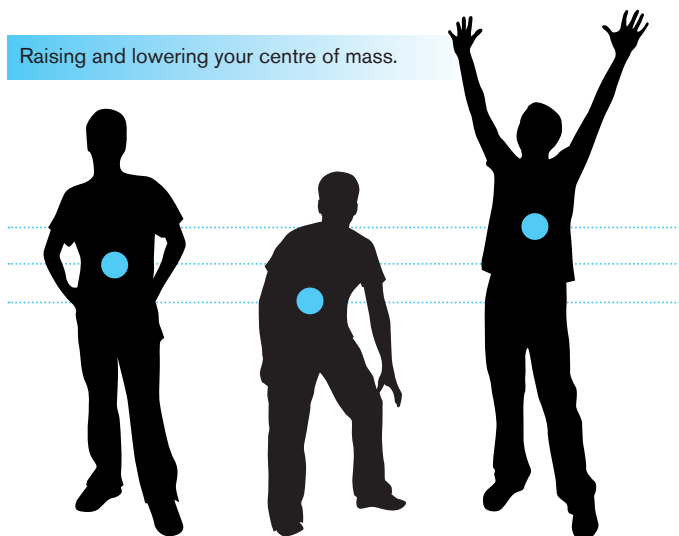
- Changing direction quickly, with and without the ball.
- Paying more attention to body movements when practising any skill.
- Trying to repeat any movement performed with its mirror image.

USEFUL PHYSICS IDEAS

An object will topple over if its centre of mass (or centre of gravity) is not over the base of the object. A person can make themselves more stable by lowering their centre of mass (making their body lower) and increasing the width of their base (moving their feet further apart).

Keywords: centre of mass, base.

Raising and lowering your centre of mass.



RESOURCES

Download a football record sheet for this session from iop.org/football

- Age/capability-appropriate footballs
- Cones
- Pens, pencils, clipboards, record sheets.

SUGGESTED STRUCTURE AND TIMINGS



In pairs, passing while observing the other's body position.



Shuttle-run competitions, keeping low when turning.



Dribbling around cones, keeping arms down to lower one's centre of mass.



In pairs, practise favourite skills, observing each other's body position.

COACHING POINTS

CAUTION: Before starting, students' warm-up should include multi-directional movements. Space out the groups to reduce the risk of being hit by balls from other groups.

Arrange cones for shuttle runs (four cones, four-yard intervals) and for dribbling practice (eight cones, two-yard intervals).

Encourage students to be more self-aware of their body movements.

They can watch each other as well as try to feel what different parts of their body are doing.

FURTHER PRACTICE

Students can be encouraged to:

Practise shuttle runs, low body position and changing direction quickly.

Practise dribbling, low body position and changing direction quickly.

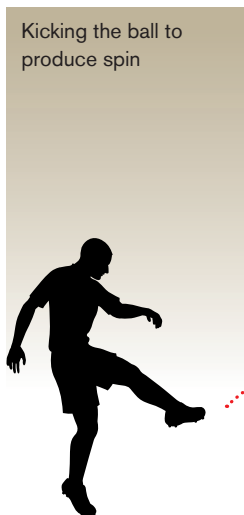
Try using both feet.

Watch how professional players move and try to copy this.

SESSION 8

HOW CAN YOU SPIN AND BEND THE BALL?

Footballers sometimes kick across the ball, rather than straight through it, to impart spin on the ball. This enables them to make it follow a curved or bent path. How the ball moves depends on the direction of swing of the kick and the point of contact on the ball.



OBJECTIVES

Students should practise:

- Different ways of kicking across the ball to get spin.
- Exploring sidespin with the inside and outside of the foot.
- Exploring backspin and topspin and trying to kick it with no spin.

USEFUL PHYSICS IDEAS

When a kicked ball is made to spin, it has an additional force on it that is perpendicular (at right angles) to its direction of travel. This changes the path it takes through the air, depending on whether it is given backspin, sidespin or topspin.

Keywords: spin, curve, force, perpendicular.

RESOURCES

Download a football record sheet for this session from iop.org/football

- Age/capability-appropriate footballs
- Cones to act as tees to help less capable explore spinning and bending
- Pens, pencils, clipboards, record sheets

SUGGESTED STRUCTURE AND TIMINGS



Working in pairs, practise kicking across the ball to explore spinning it.



In pairs, develop and improve sidespin with inside and outside of foot.



In pairs, develop and improve backspin and topspin.



In pairs, practise their favourite type of spin.

COACHING POINTS

The natural sidespin and bend that comes from an angle kick (using the sweet spot or bone in line with the big toe) is a good starting point.

Students can also use the outside of the foot to give sidespin in the opposite direction.

Emphasise that they should not be kicking through the centre of the ball.

Try exaggerating the bend for a free kick, imparting backspin and topspin.

FURTHER PRACTICE

Students can be encouraged to:

Practise different ways of kicking across the ball to get spin – initially with a soft/light ball indoors or in restricted space.

Get more bend with the inside of the foot and some bend with the outside of the foot.

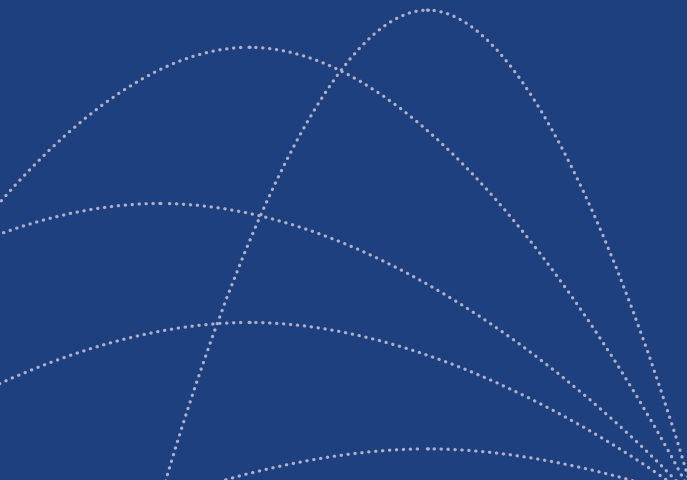
Practise chipping the ball or a more advanced backspin pass as well as using the top of the foot to volley with topspin.

Use both feet and when a skill has been mastered try it in a match.

NOTES

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