



TOPIC EXPLORATION PACK

Theme: Motion and Forces

February 2015



A Level Physical Education

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This activity offers an opportunity for English skills development.



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Introduction

AS and A Level specifications must require students to develop knowledge and understanding of motion and forces, and their relevance to performance in physical activity and sport.

Aims and objectives:

1. Define Newton's Laws of Motion, using practical sporting examples.
2. Describe the types of motion produced (linear, angular and general).
3. Describe the effect of size of force, direction of the force and the position of application of force on a body.
4. Define centre of mass and describe the effect on stability.

Topic overview

The Biomechanics section of the specification introduces students to Newton's laws of motion, and requires them to apply each of these laws to sporting examples. The three laws should be delivered in numerical order and students need to recall these in the correct order. Students will be required to demonstrate their understanding of the laws of motion by applying each law to a range of sporting examples. Specific examples from sport should be provided to the students, such as; penalty kick in football; tennis serve; shot put, that will enable them to demonstrate their understanding.

The students will be required to describe three different types of motion produced in sport and provide relevant examples for each. Specific examples from sport should be provided to the students, such as; shot put, sprinting, javelin, etc. that will enable them to demonstrate their understanding through practical application. It should be noted that students will need to be very specific when linking a type of motion with a sporting action (for example, the leg and arm action of a sprinter is angular motion whereas the torso is linear motion). Students will be required to understand the type of force required to produce the different types of motion and how this relates to the centre of mass. Practical activities can be used to let the students experience and create the different types of motion (for example, getting them to produce spin on a tennis ball or swerve on a football, etc).

Students will also learn about the effect of the size of a force on a body. Practical activities can also be used here to consider this aspect (for example, who can kick a ball the hardest, who can throw a shot put furthest, etc). Students should be encouraged to link this with the impact of muscle size and contractions.



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An understanding of the effect of the centre of mass on stability will be required by students, and they will need to understand how being stable is important in some actions (boxing stance), whereas being less stable is important in others (somersault on a trampoline). Other factors to consider are the height of the centre of mass, the line of gravity and the base of support.





Suggested activities

Activity 1: Newton's Laws of Motion

Provide the students with the laws of motion definitions and an initial sporting example for each. The activity will then require them to apply the laws to a further three sporting examples. Students should be encouraged to work individually initially and then work with a partner to compare answers and explain to each other their answers.

Activity 2: Types of Motion

Having provided the students with the definitions of linear, angular and general motion, they will then be provided with an example of each. The students will then be provided with the picture sheet (containing 10 different sporting actions) and will be required to label the pictures with the appropriate type of force being generated. (Note that if both linear and angular are present then this is general motion).

Activity 3: Size, direction and position of force

Students will be required to demonstrate their understanding of this topic through completion of a worksheet.

Activity 4: Centre of mass and stability

Students will be presented with a range of pictures of sports performers and required to locate and label the position of the centre of mass on each picture. This can then be followed up with the students having to draw the line of gravity (directly down from the centre of mass), the height of the centre of mass, and the position of the base of support. These factors all contribute to the stability of the performer. It should be noted that there are times when stability is required (stable defensive position in boxing) and times when being unstable is required (when performing a somersault).

Activity 5: Practical session

A practical session can be organised in which the students will be able to demonstrate their understanding of the Biomechanics topic through experiencing a range of practical tasks. The students will be expected to apply Newton's Laws through undertaking a practical activity. This could be via a trampolining session, and the completion of an accompanying worksheet. Alternatively, the shot put could be used. Students will be prompted through the worksheet to consider how each of the laws applies to the activity (eg the trampolinist will remain stationary until they apply a force to the trampoline bed, etc).



Answers to activities

Activity 1: Newton's Laws of Motion

Sporting example	Newton's first law	Newton's second law	Newton's third law
Penalty in football	The ball will remain at rest on the penalty spot, until a force is applied upon it from the boot of the footballer. The football will continue to travel in the direction that it was kicked until another force is applied to it (goalkeeper, hitting the net or post).	The greater the force applied by the footballer, the greater the acceleration of the ball.	The foot of the footballer will apply a force to the ball, and the ball will provide an equal and opposite reaction force to the foot of the footballer. If the ball hits the cross-bar, an equal and opposite force is applied by the cross-bar to the ball, resulting in an equal and opposite reaction (the ball bouncing back off the cross-bar).
Shot put	The shot put will remain stationary in the hand of the shot putter until they apply the force to the shot. Once thrown the shot put will continue at a constant speed until it hits the ground.	The larger the force applied by the shot put thrower, the greater the increase in acceleration.	The shot put exerts a force on the ground when it lands, and the ground will exert an equal and opposite reaction force to the shot.
Tennis serve	The force applied by the racket to the tennis ball, causes the ball to change direction. The tennis ball will continue to travel in the direction that it was hit until another force is applied to it (hits the ground, hits the net, etc).	The larger the force applied by the racket, the greater the acceleration of the tennis ball.	The tennis racket applies a force to the tennis ball and the tennis ball applies an equal and opposite reaction force to the tennis racket. If the tennis ball hits the net, the net will apply an equal and opposite force to the ball.
Snooker shot	The cue ball will remain at rest until the force is applied upon it by the cue.	The cue ball will accelerate in proportion to the size of the force applied by the cueing action.	Upon hitting the cushion the snooker ball will apply a force upon the cushion, and the cushion will apply an equal and opposite reaction force upon the snooker ball.

Activity 2: Types of Motion



Angular motion at the leg action and wheels of the bike.

Linear motion of the torso of the cyclist and the frame of the bike.



Angular motion of the arm action of the badminton player.

Linear motion of the shuttlecock.



Angular motion of the leg and arm action of the footballer.



Angular motion of the arm action of the thrower.

Linear motion of the shot put.



Angular motion of the arm action of the golfer.
Linear motion of the torso of the golfer.



Linear motion of the body of the performer and of the bobsleigh.



Angular motion of the leg and arm action of the long jumper.
Linear motion of the torso of the long jumper.



Angular motion of the arm action of the netballer.



Activity 3: Size, direction and position of force

1. The world record speed recorded for a tennis serve is approximately 150mph. Discuss how the size of force affects the speed of a tennis serve. What could a tennis player do in order to increase the speed of their serve?

The greater the size of the force applied by the arm action of the tennis player, the faster the tennis ball will travel. A tennis player usually drops their speed for the second serve (in order to increase accuracy) by reducing the force applied to the tennis ball. If a tennis player has a faster serve than their opponent it is because they are applying more force. A tennis player could work on increasing the size and strength of the muscles required in a tennis serve (deltoids, triceps brachii, etc), in order to be able to serve faster.

2. In relation to the Javelin, discuss how the size and direction of the force affects the distance thrown.

The greater the size of the force applied by the arm action of the javelin thrower, the greater potential the javelin has to travel further. This will however depend upon the direction of the force. A poor technique may result in the direction of the force being aimed towards the ground and therefore the javelin will not travel to its potential distance.

3. In relation to a penalty kick in football, discuss how the direction of the force is important for both the penalty taker and the goalkeeper.

The football will travel in the direction in which the footballer applies the force. If the force applied is in the direction of the goal then the ball will be on target, if the force applied is not in the direction of the goal then the ball will be off-target. For a goalkeeper, if they get their hand to the ball, the ball will rebound in the direction of the force that they have applied to the ball therefore it is important that they apply the force away from the goal.

4. What is a direct force? Discuss the impact of a direct force on a sporting object.

A direct force is when the line of force passes through the centre of mass of a body, resulting in linear motion. For example, a shot putter applies the force directly through the centre of mass of the object, causing the shot put to produce linear motion in a curved line.

Activity 4: Centre of mass and stability

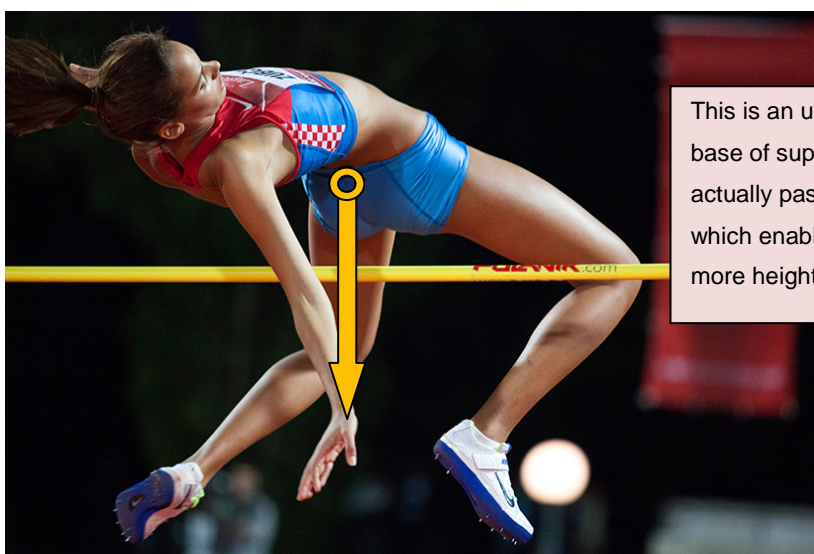
Label each of the following pictures with the following:

- Position of the centre of mass
- Line of gravity
- Base of support



This is very stable position. It is a wide base of support. The line of gravity is directly over the base of support, but slightly forward from the centre. This will allow him to resist the force of a punch more efficiently, and also provide him with forward momentum when throwing a punch.

The boxer will shift his centre of mass, and become less stable when performing a punch or dodging his opponent's punch.

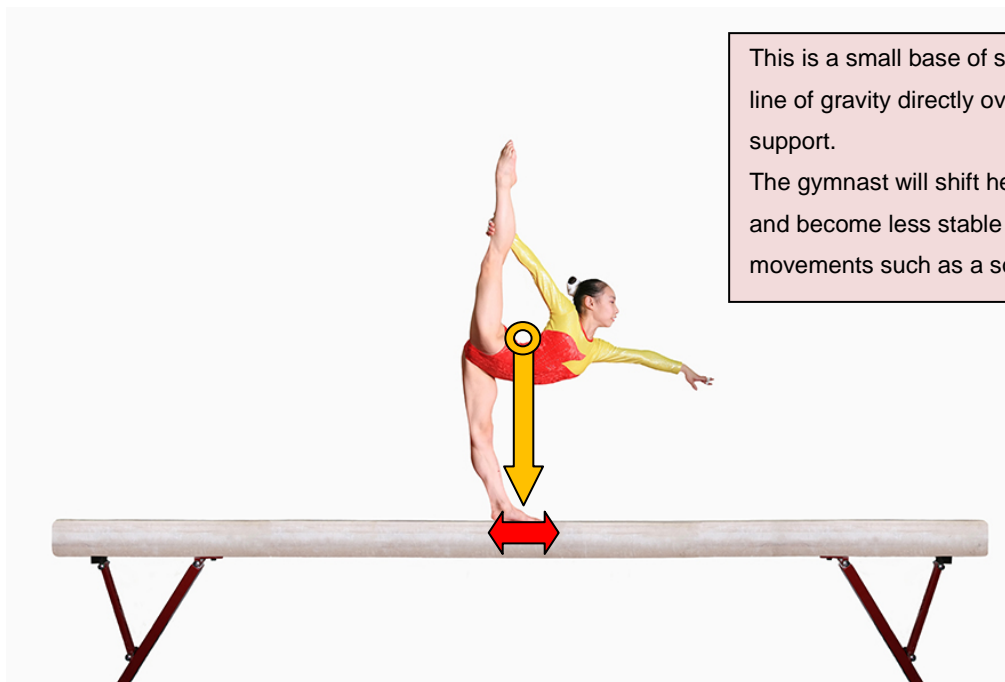


This is an unstable position. There is no base of support and the centre of mass actually passes underneath the bar, which enables the high jumper to gain more height.



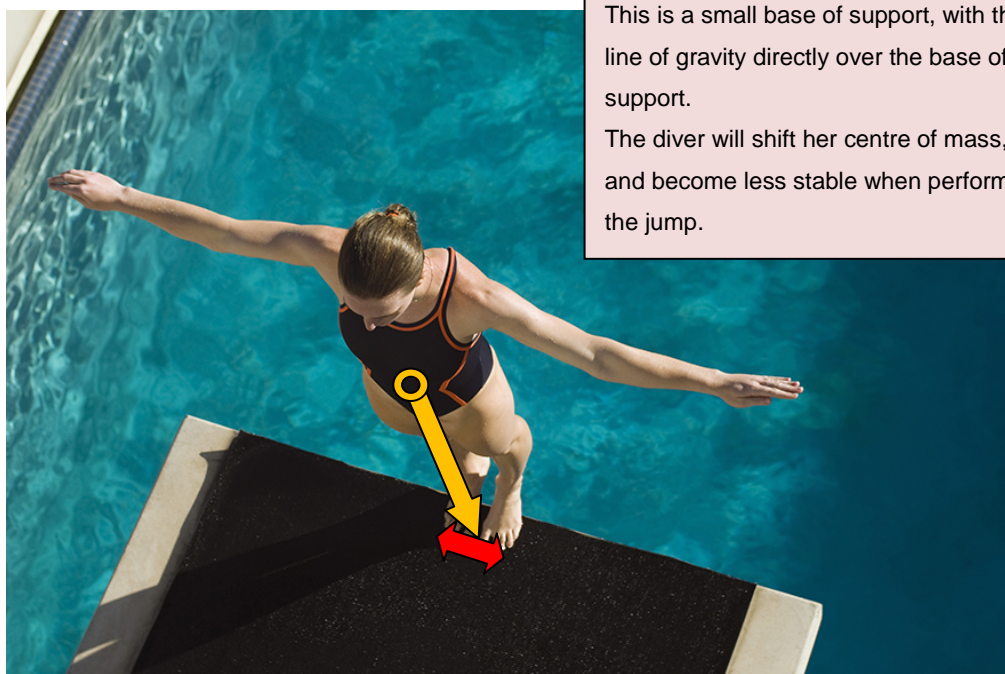
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This is a small base of support, with the line of gravity directly over the base of support.

The gymnast will shift her centre of mass, and become less stable when performing movements such as a somersault.



This is a small base of support, with the line of gravity directly over the base of support.

The diver will shift her centre of mass, and become less stable when performing the jump.



This is an unstable position. There is a very small base of support (the pole), and the line of gravity is not directly over the base of support. This allows the pole-vaulter to gain forward and upwards momentum to generate the height required.



This is very stable position. There is a wide base of support, with the line of gravity directly over the base of support but slightly forward from the centre. The basketball player will shift his centre of mass, and become less stable when trying to dribble around his opponent.

Now consider the stability of each of the performers, and if a stable or unstable position will aid performance.



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