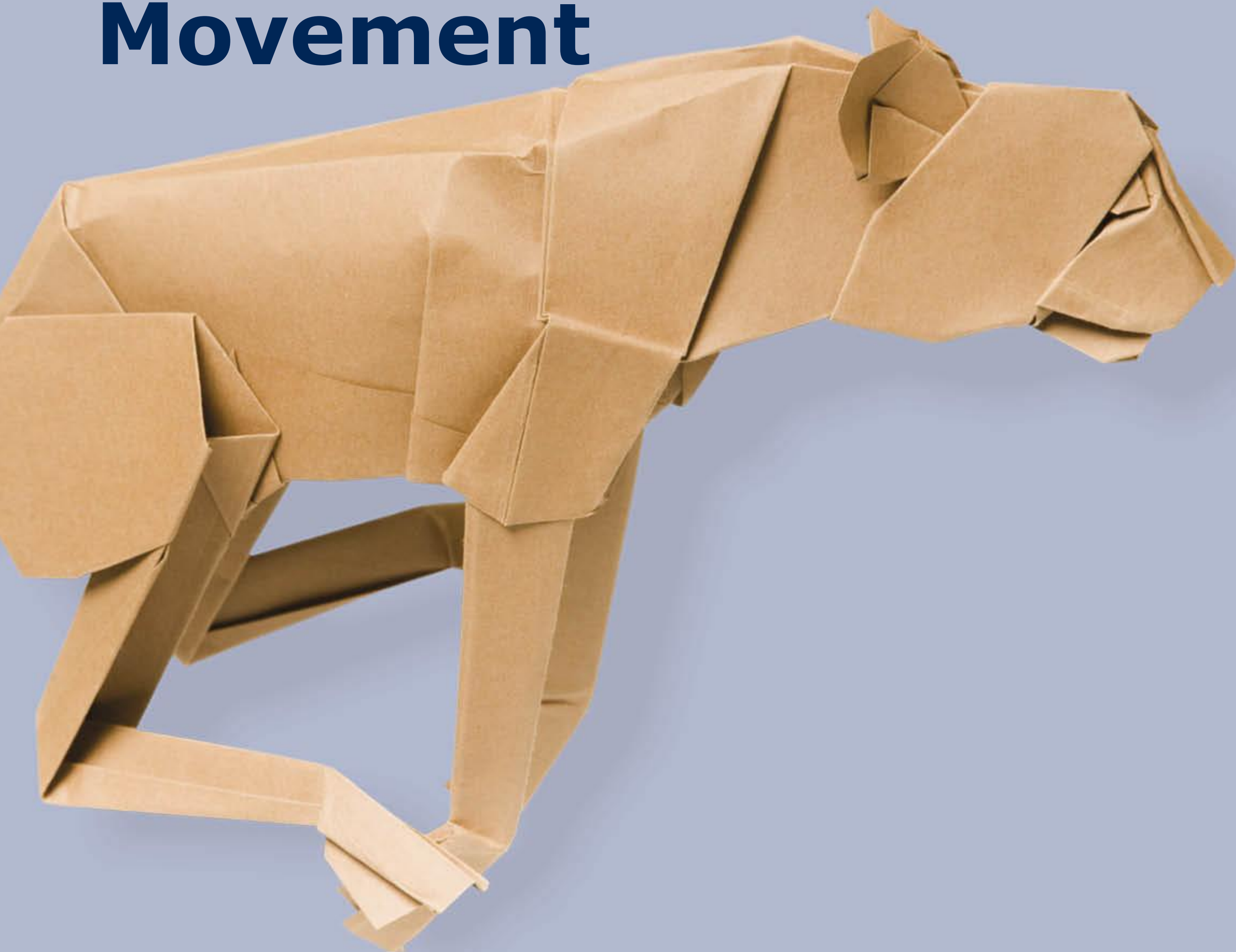
Topic Guide: Biomechanical Movement



AS and A Level Physical Education – version 2

Pearson Edexcel Level 3 Advanced GCE in Physical Education (9PE0)

Pearson Edexcel Level 3 Advanced Subsidiary GCE in Physical Education (9PE0)

GCE Physical Education 2016 Component guide 3: Biomechanical movement

Contents

Introduction

The specification has been developed in consultation with the teaching community, higher education, learned societies and subject associations. Tutors from a range of schools and colleges – in focus groups, phone interviews and face-to-face conversations – have provided feedback at each stage and have helped us to shape the specification. Physical Education academics in UK universities have helped us understand how to build on the strengths of the 2008 A level specification and advised on how progression to undergraduate study could be improved.

Component Guide 3: Biomechanical movement provides an overview of the new specification relating to this topic, to help you get to grips with the changes to content and assessment, and to help you understand what these mean for you and your learners.

Overview of changes

From September 2016, GCE Physical Education will be a linear qualification. This means that all examinations must be sat at the end of the two-year course. From September 2016, AS level Physical Education will be a stand-alone qualification. This means that it cannot be used to contribute towards an A level Physical Education grade. More information about the changes to subject content are given later on in the guide.

Each award will have two examinations – a scientific exam and a Psychological and Social exam. This is a change from 2008. The science examination comprises Topic 1: Applied anatomy and physiology and Topic 2: Exercise physiology and applied movement analysis. A new topic area is Biomechanical movement, which is embedded within both the anatomy and the physiology. This is a topic area that was not included in the 2008 specification.

There is an increased focus on the theoretical content, now worth 70 per cent of the grade.

The subject content includes a more detailed need to develop quantitative skills – now worth up to 5 per cent of the qualification.

Learners will be able to demonstrate an understanding of movement analysis through the use of examples to include linear motion, angular motion, projectile motion and fluid mechanics.

Where AS differs from A level:

All learners will cover the anatomy and physiology section of movement analysis – to include levers, newton's laws, calculation of forces and stability.

Those who go on to study A level will also complete the exercise physiology part and be able to demonstrate an understanding of movement analysis through the use of examples to include **2.4 Linear motion, 2.5 Angular motion, 2.6 Projectile motion** and **2.7 Fluid mechanics**. A level topics are shown in bold type throughout the booklet.

Key content

Topic 1: Applied anatomy and physiology

Topic 1.1.4

The components of an anatomical lever are the fulcrum (F), where the force is applied (effort) (E) and the load/resistance (R). The relationship between these determines the type of lever.

Examples: www.slideshare.net/spanglerscience/muscle-leversppt-presentation

Learners must have knowledge and understanding of how the body uses the lever systems (1st, 2nd and 3rd class) in physical activity and sport. This should include the mechanical advantages and disadvantages of each lever. For example, the further it is between the fulcrum and the resistance the greater speed that can be generated. The greater distance between the effort and the fulcrum the less effort is required to move a resistance. In sport, rackets are often used to increase this length, which will increase the force that an object is struck with. Mechanical advantage is the relative efficiency of the lever because the optimal length of an implement is determined by the strength of the performer. For example, learners should be able to analyse the effects different techniques on performance, such as an athlete throwing a javelin with a bent or straight arm.

Useful resources:

- http://sciencelearn.org.nz/Contexts/Sporting-Edge/Looking-closer/What-levers-does-your-body-use?
  www.humankinetics.com/excerpts/excerpts/levers-work-to-create-movement-in-the-human-body
- https://www.youtube.com/watch?v=ny8k7LUUIEk

  This clip has examples of each of the three classes of levers

Topic 1.1.5

Newton's Three Laws of Motion

All three laws need to be understood, learners must have a knowledge and understanding of the laws and how each applies to a sporting example.

Useful resources:

- www.sports-training-adviser.com/lawsofmotion.html
- www.runningwithteamhogan.com/curling-and-newtons-laws-of-motion-using-olympics-to-teach-physics
- www.proteacher.org/c/972_laws_of_motion.html

1. Newton's First Law/The law of inertia)

Every object in a state of uniform **motion** tends to remain in that state of **motion** unless an external force is applied to it.

An example of the law of inertia can be seen in a volleyball at the highest arc of a server's toss, that moment when the ball is nearly motionless. It will either fall straight down due to the force of gravity, or sail across the net from the force of a hand striking it. In an example of a moving object, a spiked volleyball moves in a fairly straight line downwards unless deflected by the force of the net, receiver's forearms, blocker's hands or floor.

2. Newton's Second Law/The law of acceleration

Learners should be using 9.81 m/s^2 as acceleration due to gravity. The weight of an athlete is their mass multiplied by 9.81 m/s^2.

The calculation of force and resultant force: a mass of 1kg exerts a force of 9.81N (10N will be accepted as you can see in the mark scheme on the Sample Assessment Materials question 2, in case learners do not have a calculator). Learners must be able to do a calculation of Force (mass x acceleration).

The law of acceleration, states that an increase in the velocity of a moving object is directly proportional to the force applied and inversely proportional to the object's mass. The object will accelerate in the direction of the external force.

Force=Mass x acceleration.
And Acceleration = force divided by mass.

For example:
Volleyball: The faster the arm swing (acceleration), the more force is exerted on a spiked volleyball at the moment of contact.

Basketball: When you shoot the basketball, it will accelerate in direction of the force exerted on it by the player. If the player shot a ball weighing 0.62kg with 3.2N of force from the free throw line, and then used the same amount of force to shoot once again from the 3-point line, the ball would not make it. This is due to the fact that the force would be too low for the distance and acceleration would also decrease.

Or, if a person were to throw a larger object like a bowling ball with the same force, the net force on the bowling ball would be less, acceleration would also decrease, and it would not go as far.

3.Newton's Third Law/ The law of action and reaction

For every action there is an equal and opposite reaction. For example, in weight lifting the lifter exerts a force on the weight to hold it above their head, but gravity exerts an equal and opposite force of their weight back down to the ground.

Other useful resources include:

- https://www.youtube.com/watch?v=MAm6LOUnJ80
  provides practical examples of all three laws
- https://www.youtube.com/watch?v=iwP4heWDhvw
  Second Law practical example with rocket firing
- https://www.youtube.com/watch?v=R8qygu1RUOI
  An applied practical example of 3rd law in Basketball
- https://www.youtube.com/watch?v=8eL0ESxP9dI
  Three laws demonstrated on a trampoline
- https://www.youtube.com/watch?v=F9COtJBBzhk
  Three laws demonstrated in skateboard/BMX

Topic 1.1.6

Learners should be aware of the principles related to the stability of the body in relation to the centre of mass. Being stable, unstable or neutral depends on the position of the line of gravity relative to the limits of the base, the weight of the body and the height of centre of gravity relative to the base. This is applied in sport, for example a swimmer at the start of a race has the line of gravity close to the forward limit of the base so when the gun goes off they can move forward easily. This is also seen when a track athlete rocks forward into the set position in athletics.

Useful resources include:

- https://www.youtube.com/watch?v=xBsuBgFOE-U
  Considers stability and centre of mass relationship

Topic 1.1.7

The calculation of force and resultant force: a mass of 1kg exerts a force of 9.81N (10N will be accepted as you can see in the mark scheme on the Sample Assessment Materials in case learners do not have a calculator). Learners must be able to do a calculation of force (mass x acceleration).

Topic 2: Exercise physiology and applied movement analysis

2.4 Linear motion

Linear motion requires learners to understand how to calculate speed (how fast an object is travelling). Speed is a scalar quantity (no direction is considered). Learners will also need to understand velocity. This is a vector quantity and therefore has size and direction. Both are measured in metres travelled per second.

- **www.physicsclassroom.com/class/1DKin/Lesson-1/Speed-and-Velocity is a useful website for an explanation of this.**

Acceleration is the rate of change in velocity. It is also a vector quantity (has magnitude and direction).

- **www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/forces/represmotionrev4.shtml has a simple explanation of this.**

Learners will need to be able to draw graphs and to complete calculations of the distance and displacement, speed and average speed, velocity and acceleration. Speed = distance/time (s =d/t) Velocity = displacement/time or distance/time (m/s) Acceleration = (final velocity – initial velocity)/time taken (m/s^2). They will also need to be able to plot, label and interpret graphs of motion. To include distance/time, speed/time graphs and velocity/time graphs. For example, in the Sample Assessment Materials Q9aii in the A level Scientific Principles paper with its mark scheme showing the graph.

- **www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_pre_2011/explaining_motion/describingmotionrev2.shtml has examples of such graphs.**

2.5 Angular motion

Angular motion is about when something rotates such as a diver or gymnast somersaulting. The principles that applied to linear motion also apply to angular motion i.e. velocity, displacement and acceleration.

Learners will need to know the factors affecting moment of inertia which are mass and distribution of mass from axis of rotation.

- **www.saburchill.com/physics/chapters/0022.html has a good explanation of this.**

Learners must understand the effects of increasing or decreasing the moment of inertia when rotating about an axis (whole body or specific joint).

- **www.wired.com/2012/08/diving-and-the-moment-of-inertia/ This is in more detail than learners need, but a useful background read for tutors.**

For example, in a somersault, when moment of inertia is decreased (by tucking arms in) the angular velocity is increased, therefore an increase in rotations. On the other hand, if a diver wanted to enter the water straight and controlled they would straighten their body to increase the moment of inertia. This in turn would slow down rotation and reduce angular velocity. Learners should be able to use this knowledge to analyse techniques, for example to explain why a performer may have over or under rotated when performing a somersault on a trampoline.

Conservation of angular momentum during flight, moment of inertia and its relationship with angular velocity refers to the fact that angular momentum stays the same so to slow down a gymnast or diver needs to extend out of the tuck position before they land.

2.6 Projectile motion

Learners will need to understand practical examples of projectile motion and show knowledge, understanding and application of projectile motion in refining technique in different sporting contexts. For example, the angle that you release an object at in athletics field events.

There are forces acting during flight that affect projectile motion: gravity, air resistance and lift forces. Learners must be able to analyse how these factors affect different sporting events.

- **www.study.com/academy/lesson/projectile-motion-definition-and-examples.html is a useful look at projectile motion.**

There are also factors that determine the horizontal displacement of a projectile: velocity of release, height of release and angle of release. Discussing how an athlete may modify technique to take these into account will be important. A coach may modify technique or there may be technique or technology changes to equipment to facilitate this.

2.7 Fluid mechanics

This topic considers when a force acts because something moves through air or water. Learners will need practical examples to support their theoretical knowledge. Examples such as swimming through water and flight of tennis balls or cricket balls through air will assist in the understanding of this topic. For example, how are flight paths for a shot put, a tennis ball and a shuttlecock different, and analyse why.

There are various factors affecting fluid friction and air resistance: velocity, drag force, mass, streamlining and surface characteristics of body. Learners will need a knowledge and understanding of these factors and to apply them to an example, such as the swimmer who wears a particular design of swim suit to assist with streamlining and reduction of drag forces. Knowledge of this topic will also enable learners to understand how it has influenced technological advancements in technique modification, clothing/suits and equipment/apparatus.

For example, air resistance will affect these events: sprinting, cycling, projectiles such as shot put, shuttlecock and tennis ball and a javelin throw.

Learners need an understanding of interaction of lift forces with objects: upward and downward lift forces, angle of attack and the Bernoulli effect. These topics are discussed in Wesson, et al.'s textbook in detail.

- **www.slideshare.net/klharrison/biomechanics-4 is also a useful power point on this topic area.**

Learners must have knowledge and understanding of types of spin: topspin, backspin and sidespin. Magnus effect and how they impact on flight path and bounce. For example, learners should be able to analyse the effects of different types of spin on different balls (a tennis ball, a cricket ball, etc.) and explain how it affects performance.

Detailed content changes

This entire topic is new for delivery in this specification.

Delivery approaches including ideas for practical delivery

This unit lends itself to a practical approach as much as possible.

Topic	Ideas for delivery
Levers	• Making levers models, weights session in a gym identifying the different levers, demos (including opening a door, tightening a nut with fingers and then spanner, nut crackers, crow bar, using a screwdriver to open a tin of paint, arm wrestling, cutting a thin piece of paper and then thick card using only the points on scissors). • Watch the following YouTube video on levers www.youtube.com/watch?=VSAtPQBhoGg (class 1, 2 and 3 levers with exercise examples) then create your own YouTube video explaining the levers with practical examples of your own. Your own videos must include advantages and disadvantages.
Newton's Three Laws of Motion	• Tennis play – forces acting on the tennis ball in different scenarios. • Use practical examples to illustrate all the laws: o Newton's 3rd law – ice skater standing at the wall pushes on wall and goes back or letting go of a blown up balloon (balloon moves opposite direction to movement of air) o Watching a rugby tackle and what happens to both players. o Time everyone running 10m, 20m, 30m, 40m, 50m, etc. graph times. Use a chart and calculate speeds of runners at different points. Use a compass to determine direction and calculate velocity. Calculate mass of runners and then acceleration. o Try running and stopping on different surfaces to introduce friction. o Observe a game of kickball and then write a

	paragraph using the words motion, time, distance velocity, speed, acceleration, force, friction and inertia. ○ Newton's 3rd law – via bouncing basketballs – the harder you push down the more it bounces up. Think of their own practical examples using words force, exert, action and reaction. ○ Newton's 2nd law by penny push (coin collision) – push two coins into each other and observe what happens. Create a prezi using Newton's three laws of motion – must be applied to practical examples. ○ Use curling to teach Newton's laws: www.runningwithteamhogan.com/curling-and-newtons-laws-of-motion-using-olympics-to-teach-physics ○ Watch a space rocket launch for Newton's laws of motion. ○ For lots of practical ideas about teaching this topic go to: www.proteacher.org/c/972_laws_of_motion.html
Calculation of forces	• Practical examples and attempt calculations.
Linear motion	• **Calculations of distance travelled, or use of apps to record distances travelled. Do practical calculations of split times, acceleration and velocity in different events. E.g. Usain Bolt in every 10m of a 100m race and compare to your scores.** • **Draw distance-time graphs.** • **Draw velocity-time graphs or speed-time graphs using practical investigations. Be able to comment on the gradients.**
Angular motion	• **Trampolining or gymnastics practical to include rotations, twists and spins plus observations of elite diving, trampoline and gymnastics clips. For example, turn with arms in and out to spin faster, tuck v pike somersaults to observe differences in speed of rotation.** • **Mark different axes of rotation on a diagram of a skeleton.**
Projectile motion	• **Practicals in athletics field events looking at angles of release – analysis through videoing and comparison to perfect model. Calculate angles of release and distance achieved.**
Fluid mechanics	• **Use of tennis spins and cricket ball spins as examples, reduction of drag in bikes, learners designing new aerodynamic clothing for a sport of their choice, looking at kit and equipment and how it is designed.** • **Practicals where learners do the different types of spin themselves with tennis and cricket balls.** • **Swimming is a good example for drag and streamlining.**

Quantitative skills guidance

These topics fit very well with the quantitative skills requirement. They lend themselves to calculation style questions.

Examples might include:

- Drawing, plotting and interpreting distance-time, or velocity-time or speed-time graphs and being able to analyse and interpret them.
- Calculating mass, forces, resultant forces, speed, velocity and acceleration. You must remember to use the correct units.

Sample questions

Regular testing of learners on the key terms in the glossary that are part of the specification is important (see Appendix7, page 88).

When practising questions ensure that tutors and learners are using the command words in the specification and that learners understand the requirements of each command word.

The Sample Assessment Materials contain examples of Biomechanical movement questions. In the A level SAMs there are questions 2A and 9A.

In the AS SAMs there are example questions numbers 6a and b.

To ensure understanding questions could be given to learners starting:

- Newton's… law is used…
- Calculate…
- Graph…
- Using examples explain the…
- Linear motion…
- Fluid mechanics…
- Projectile motion is used in sport…
- Angular motion helps us to understand…

Resources and references

Useful textbooks

- Burkett, B. (2010) *Sports mechanics for coaches*, Champaign, IL: Human Kinetics
- McGinnis, P. (2013) *Biomechanics of Sport and Exercise*, Champaign, IL: Human Kinetics.
- Blazevich, A. (2010) *Sports Biomechanics: The Basics: Optimising Human Performance*, London: A&C Black Publishers (new edition coming out in Jan 2016)
- Hay, J. (1993) *The Biomechanics of Sports Techniques (Fourth Edition)*, Upper Saddle River, NJ: Prentice Hall
- Wesson, K., et al. (2005) *Sport and PE: A Complete Guide to Advanced Level Study (Third Edition)*, London: Hodder Education

Useful websites

Levers:

- www.sciencelearn.org.nz/Contexts/Sporting-Edge/Looking-closer/What-levers-does-your-body-use
- www.humankinetics.com/excerpts/excerpts/levers-work-to-create-movement-in-the-human-body
- www.brainmac.co.uk/levers

Newton's Laws of Motion:

- www.sports-training-adviser.com/lawsofmotion
- www.runningwithteamhogan.com/curling-and-newtons-laws-of-motion-using-olympics-to-teach-physics
- www.explainthatstuff.com/motion.html
- www.proteacher.org/c/972_laws_of_motion.html

Linear motion:

- www.physicsclassroom.com/class/1DKin/Lesson-1/Speed-and-Velocity
- www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/forces/represmotionrev4.shtml
- www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_pre_2011/explaining_motion/describingmotionrev2.shtml

Angular motion:

- www.saburchill.com/physics/chapters/0022.html
- www.wired.com/2012/08/diving-and-the-moment-of-inertia/ (background reading for tutors)

Projectile motion:

- www.study.com/academy/lesson/projectile-motion-definition-and-examples.html
- www.bases.org.uk/biomechanics
- www.physicstutorials.org/home/mechanics/1d-kinematics/projectile-motion

Fluid mechanics:

- http://www.slideshare.net/klharrison/biomechanics-4 edexcel