GCE AS

eduqas
Part of WJEC

WJEC Eduqas GCE AS in

GEOGRAPHY

ACCREDITED BY OFQUAL

GUIDANCE FOR TEACHING

Teaching from 2016

wjec
cbac

This Ofqual regulated qualification is not available for candidates in maintained schools and colleges in Wales.

Contents

Introduction

The WJEC Eduqas AS in Geography specification encourages learners to apply geographical knowledge, theory and skills to the world around them. In turn, this will enable learners to develop a critical understanding of the world's people, places and environments in the 21st century. Learners should be able to develop both knowledge and understanding of contemporary geographical concepts, together with transferable skills, that will enable learners to progress to higher education and a range of employment opportunities.

The focus of the specification is to develop an enthusiasm for and competence in geography by using contemporary real-world contexts, from a range of specified spatial scales, and through engagement with and practical application of geographical skills and techniques in the field. This specification draws on both physical and human geography, explores people-environment interactions and encourages development of fieldwork at local level to enable learners to pose enquiry questions.

The specification covers the required subject content at an appropriate level of rigour and challenge for a GCE AS qualification. The content is organised into the required core and a non-core themes as prescribed by the Geography GCE AS and A level subject content July 2014.

The core themes; knowledge and understanding

1) Landscape systems
2) Changing place; changing places

The non-core compulsory theme at AS is Tectonic Hazards. The specialised concepts and geographical skills (quantitative and qualitative skills and approaches) are embedded in the core and non-core content.

In addition to this Guidance support is provided in the following ways:

- Specimen assessment materials and mark schemes
- Face-to-face CPD events
- Examiners' reports on each question paper
- Free access to past question papers and mark schemes via the secure website
- Direct access to the subject officer
- Free online resources – Eduqas Digital Resources
- Online Examination Review

The specification, latest news and resources are available on the Eduqas AS/A Level Geography webpage http://www.eduqas.co.uk/qualifications/geography/as-a-level/.

Aims of the Guidance for Teaching

The principal aim of the Guidance for Teaching is to support teachers in the delivery of the new WJEC Eduqas in AS Geography specification and to offer guidance on the requirements of the qualification and the assessment process.

The Guidance is not intended as a comprehensive reference, but as support for professional teachers to develop stimulating and exciting courses tailored to the needs and skills of their own learners in their particular institutions. In addition, it must not be used instead of the specification, but must be used to support the delivery of it.

The Guidance offers assistance to teachers with regard to possible classroom activities and links to digital resources (both our own, freely available, digital materials and some from external sources) to provide ideas when planning interesting, topical and engaging lessons.

Please be aware that many of the resources mentioned in this Guidance are web-based and accessed via hyperlinks. As a result, you are advised to view this Guidance electronically.

Assessment Strategy

Assessment Objectives and examples of their related command words

The table below illustrates how the Assessment Objectives (AOs) are divided and shows where they are also sub-divided into strands and elements. Some examples of the command words that could be used in examination papers when addressing these AOs have also been included. Furthermore, the final column includes some sample questions to give an example of how the various AOs would be addressed in an examination paper.

Assessment Objective	Strands	Elements	Example Command Words	Example Questions from Sample Assessment Materials
AO1 Demonstrate knowledge and understanding of places, environments, concepts, processes, interactions and change, at a variety of scales.	N/A	This AO is a single element.	Define Identify State Describe Distinguish Explain Give an example Outline	Define the term quaternary industry. [2] Describe how the process of gentrification leads to changes in the characteristics of places. [6]

AO2 Apply knowledge and understanding in different contexts to interpret, analyse and evaluate key geographical information and issues.	N/A	1a – Apply knowledge and understanding in different contexts to analyse key geographical information and issues.	Analyse Compare Contrast Explain why	Explain why seasonal changes in the polar ice mass balance are the result of variations in inputs and outputs. [6]
		1b – Apply knowledge and understanding in different contexts to interpret key geographical information and issues.	Suggest Interpret	Suggest one reason why rates of coastal erosion vary. [2] Suggest how tourism can affect local rural communities. [8]
		1c – Apply knowledge and understanding in different contexts to evaluate key geographical information and issues.	Assess Discuss Justify Evaluate Examine To what extent	Examine why some people have benefited more than others from recent changes in the central areas of cities. [15] – AO1 (10); AO2.1c (5)

AO3 Use a variety of relevant quantitative, qualitative and fieldwork skills to: • investigate geographical questions and issues • interpret, analyse and evaluate data and evidence • construct arguments and draw conclusions.	1 – investigate geographical questions and issues.	N/A	Calculate Describe (pattern/variations) Draw Identify Label State Select Estimate	Use Figure 3 to describe variations in the rates of change in the polar ice mass. [5] Use Figure 5 to describe the concentration of digital companies in the UK. [5]
	2 – interpret, analyse and evaluate data and evidence.		Explain Compare Suggest	Use Figure 2 to compare the coastline dynamics of Klaipeda and Kaliningrad. [5] Use Figure 4 to analyse changes to this landscape between 1992 and 2009, caused by climate change. Include relevant data in your answer. [5]
	3 – construct arguments and draw conclusions.		Analyse To what extent Assess Discuss Evaluate	

Adapted from GCE Subject Level Guidance for Geography March 2015.

Command Word Glossary

The table below provides a full list of command words that could be used in future examination series, along with a definition of each.

Define	Give the precise meaning of a term, phrase or concept.
Identify	Point out and name from a number of possibilities.
State	Give a specific name, value or other brief answer without explanation.
Describe	Identify distinctive features and give descriptive, factual detail. Describe how...
Distinguish	Make clear the differences between two or more concepts.
Explain	Give an account; factual detail e.g. of a process.
Give an example	Provide accurate evidence (response given demonstrates knowledge and understanding).
Outline	Give a brief summary of the main characteristics.
Analyse	Break down in order to bring out the essential elements or structure.
Compare	Give a point by point identification of similarities and differences.
Contrast	Give a point by point identification of differences only.
Explain why	Give reasons or causes and show an understanding of why something has occurred/applied to resource.
Suggest	Put forward plausible and informed ideas based on wider geographical knowledge and understanding.
Interpret	In relation to NEA and skills – bring out the meaning, explain.
Assess	Goes beyond knowledge and understanding to weigh up the importance of the subject. This means there are a number of possible explanations/arguments/outcomes. The main possible explanations/arguments/outcomes should be given with justification on which is/are favoured.
Discuss	Goes beyond knowledge and understanding to offer a considered review that includes a range of arguments or factors with more than one side of the evidence given with supporting examples. It becomes a written debate, identifying through description and explanation, both positive and negative points and reaches a conclusion from the debate.
Justify	Goes beyond knowledge and understanding to explain why the choice given is better than other possible options.
Evaluate	Goes beyond knowledge and understanding to evaluate. Requires a judgement about the overall quality or value of the feature(s)/issue(s) in terms of the strengths and limitations. Supporting evidence should be clearly given. A viewpoint, after consideration of the evidence should be given, with personal judgement/opinion.
Examine	Consider an argument or concept in a way that uncovers the assumption and interrelationships of the issue, and is often followed by the 'role of' or 'importance'.

To what extent/How far do you agree?	Goes beyond knowledge and understanding to give possible explanations for and against, and justify a viewpoint(s).
Calculate	Ascertain by reckoning.
Draw	Draw to represent, an accurate diagram or graph.
Identify	Point out and name from a number of possibilities.
Label	Add labels to a diagram.
State	Give a specific name, value or other brief answer without explanation.
Select	Pick out the most appropriate material.
Estimate	Obtain an approximate mathematical or statistical value.

Delivering the Specification

Summary of Assessment

Component 1: Changing Landscapes

Written examination: 2 hours 15 minutes
60% of qualification

Section A: Changing Landscapes
Choice between two themes, either Coastal or Glaciated Landscapes
Two compulsory structured questions with data response

Section B: Tectonic Hazards
One compulsory structured question with data response and two extended response questions

Section C: Challenges in the 21st Century
One compulsory extended response question drawing on both Components 1 and 2, with resource material

Component 2: Changing Places

Written examination: 1 hour 15 minutes
40% of qualification

Section A: Changing Places
Two compulsory structured questions with data response

Section B: Fieldwork Investigation in Physical and Human Geography
Three compulsory structured questions with data response on fieldwork and the learner's own fieldwork investigation

Specialised Concepts

Specialised concepts are relevant to the core and non-core content. These must include the concepts of:

- Causality
- Equilibrium
- Feedback
- Identity
- Inequality
- Interdependence
- Globalisation
- Mitigation and adaptation
- Representation
- Risk
- Resilience
- Sustainability
- Systems
- Thresholds

Integration of the specialised concepts are illustrated in the introduction to each component within the specification.

Amplification of Content and Learning Plans

This section gives examples of planning for each of the components. The first column of each plan is taken directly from the specification. The second gives some additional elaboration of the geographical content column in the specification. The third column provides possible learning ideas, opportunities and/or resources. Other approaches and exemplar materials are equally valid and teachers are encouraged to develop their own approaches to the specification that best suits the needs of themselves, their location and the needs of their particular learners. The approaches below are designed as guidance in order to provide starting points and are neither comprehensive nor mandatory.

Changing Landscapes – Coastal Landscapes

Focus	Amplification of Content	Teaching/Learning Approaches and Resources
1.1.1 The operation of the coast as a system.	The geomorphological content of Coastal Landscapes is specifically framed within a systems context so that learners should know and understand the physical landscape as a series of linked components through which energy and material are cycled. The **coastal system** is one of **inputs**, **outputs**, **stores** and **transfers** of **energy** and **materials**. Two sub-systems can be identified: the cliff sub-system and the beach sub-system. The cliff sub-system has inputs of the subaerial processes of weathering and the atmospheric process of wind erosion; a transfer of cliff mass movement of falls, slips and slumps and an output of sediment at the base of the cliff which is either deposited or is transported by marine processes. The beach sub-system has an input of	Construct a diagram of the coastal system http://worldlywise.pbworks.com/w/page/15409212/Unit%201%20Section%20A%20-%20How%20physical%20processes%20have%20created%20coastal%20landforms and identify inputs, outputs, stores and transfers of energy and materials. See slides 3-5 - http://slideplayer.com/slide/1372629/ Sketch a diagram of sediment inputs, sinks and transport of sand and shingle in the coastal zone, and calculate sediment budgets (see skills exercise). This example of a sediment budget approach to coastal erosion in South Carolina usefully exemplifies the application of the approach in a coastal management

	sediment from longshore drift, the cliff and offshore, a transfer of longshore drift and an output of longshore drift and destructive waves carrying sediment offshore. There are three principal **supplies of sediment**: rivers, cliffs and dunes **(terrestrial)** and the **offshore** zone. Of these, rivers are thought to be the most important. Cliff and dune erosion can also input large amounts of sediment and can be locally important. Sediments are also transported onshore by waves and currents from sandbanks in the offshore zone. These sandbanks are important sediment sinks. **Coastal sediment cells** are areas of coast usually defined by headlands within which marine processes are largely confined with limited transfer of sediment from one cell to another. The relationship between inputs and outputs is constantly changing, i.e. it is dynamic, and the system is designed to achieve an equilibrium position where inputs equal outputs. To this end, erosion, transport and deposition occur: thus the concept of **dynamic equilibrium**.	context: http://pubs.usgs.gov/of/2008/1206/html/processes1.html Annotate a map of coastal sediment cells in England and Wales http://www.slideshare.net/fozzie/sediment-cells-and-sources Highlight boundaries of one sediment cell determined by the topography and shape of the coastline. Examine the concept of dynamic equilibrium and the adjustment of beach sediments (slide 10) and cliffs (slide 34) to changing energy inputs http://slideplayer.com/slide/1372629/

1.1.2 Landforms and landscape systems, their distinctive features and distribution.	Learners should be able to identify and differentiate between **rocky coastlines** (erosional) and **sandy or estuarine coastlines** (predominantly depositional). Depositional environments tend to be lower energy but a further critical control is sediment supply, where the production and delivery of sediment exceeds rates of removal deposition. This fact emphasises the geographical linkages between areas of erosion (cliff inputs to the coastal zone) and areas of deposition to which eroded sediments are transported. **High energy** coastal environments are characterised by erosion, high wave activity, exposure to prevailing winds and a long fetch. Landforms include headlands, cliffs and wave-cut platforms (see 1.1.5). **Low energy** coastal environments are dominated by deposition, they are sheltered and characterised by low wave activity. Landforms include beaches and spits (see 1.1.6).	Coasts introduction 0–2:30 minutes: http://www.youtube.com/watch?v=ZWEJq03NBao For an outline of high energy and low energy coastal environments see slides 28–29 – http://slideplayer.com/slide/1372629/ For a comparison of high energy and low energy coastal environments of Orkney see: https://tinyurl.com/2vvzymee Classification of coastal landscapes according to landscape character type. An example of a landscape character assessment map for north Norfolk can be found at: https://tinyurl.com/32djcs6n Comparisons of characteristics of rocky, sandy and estuarine coastal environments using GIS mapping of the variety of coastal (rocky, sandy and estuarine) landscapes both for and beyond the UK (see skills exercise). https://www.arcgis.com/home/ Trace a 30–40 km coastline at a range of scales (1:1000 000, 1: 50 000 and 1:25 000), and comment on the influence of scale on the plan of the coastline (see skills exercise).

1.1.3 Factors affecting coastal processes and landforms.	Learners should know and understand how temporal variations in tides, currents and wave types influence coastal environments. The marine offshore system is driven by the effects of waves, tides and currents which are energy inputs. Diurnal variations: The energy represented by tidal currents is significant in eroding, transporting and depositing material. In estuaries, the rising tide can pick up (entrain) sediment and transport it inland. Once high tide is reached, the current reverses, transporting material in the opposite direction. Current velocities are relatively low at the start and end of each cycle and at their maximum in the middle of the rising or falling tide. Different sized particles are, therefore, entrained and deposited at different times and in different locations. Seasonal variations in wave types: Constructive waves tend to occur during the summer. Constructive waves are low, flat and gentle, with wavelengths up to 100 m and a low frequency of 6–8 waves per minute. They are characterised by a relatively more powerful swash, which carries sand and shingle up the beach, and a relatively weaker backwash. Constructive waves contribute to the formation of beach ridges and berms. Destructive waves tend to occur during storms and in winter. Destructive waves are steep in form and break at a high frequency, at 13–15 waves per minute. They	Identify how velocities and associated processes change at different stages of the tidal cycle. Read more at https://www.geographyeducationonline.org/a-level/physical-geography/coasts-tides-and-currents For a comparison of destructive and constructive waves see slides 18–20 – http://slideplayer.com/slide/1372629/ This link provides a useful video that compares destructive and constructive waves. Draw diagrams of different wave types and make notes on how they influence coastal environments. For some of the factors affecting coastal processes and landforms see: http://thebritishgeographer.weebly.com/coastal-processes.html and slides 13, 22, 23, 51–53, 60, 64 http://slideplayer.com/slide/1372629/ Calculate the maximum fetch using an atlas. Work out the maximum fetch for the following locations: Aberdeen in north-east Scotland has a fetch of _____ km Rhossili in south-west Wales has a fetch of _____ km

	have a plunging motion that generates little swash and a relatively more powerful backwash; this transports sediment down the beach face, resulting in a net loss of material. Learners should know and understand that factors including the **fetch** (the distance over which the wind has blown), **wave type** (constructive or destructive), **wave orientation**, **wave refraction** and **reflection** influence coastal processes and associated landforms. Geology (both **lithology** and **structure**) can be a major factor in coastline shape and landform creation. Beach material is often made up of locally eroded rock which will condition beach characteristics, sandy and/or pebbles and gradient. Rock type influences differential weathering and mass movement as well as the rate and type of erosion (corrosion of calcareous rocks for example), cliff angle, and whether caves, arches, stacks and stumps have a propensity to be created. Often sedimentary rocks will be eroded more quickly and, dependent upon slope-foot condition, may give rise to steep or shallow angle cliffs. Clay cliffs in particular suffer from mass movement of slumps. Igneous rocks, such as granite, erode more slowly and tend to naturally produce steep sided cliffs. Geological structure incorporating **bedding planes**, **dip**, **folding** and **faulting** can add distinctive features to coastal cliff lines such as the shape that caves take and local features such as	Dover in south-east England has a fetch of _____ km Use the formula H = 0.36√F to calculate the maximum possible wave height at these locations, as determined by fetch (see skills exercise). Estimate wave frequency: count the number of waves over a 10 minute period and divide the total by the number of minutes to determine the mean number of waves per minute (see skills exercise). Draw a wind rose of the tabulated data to show the prevailing wind direction (see skills exercise). Wave height and wind speed data – Stiff, P. (2007) *Coasts.* Oxon. Philip Allan Updates. ISBN 978-1-84489-615-8 Activity 2, p.9.

	blowholes and geos. The orientation of the geology with the coastline is very relevant in conditioning coastal landforms. If the geological trend is concordant, parallel to the coast, then coves and solid rock bars, a Dalmatian coastline, is created. A discordant coastline with differential geology at right angles to the coast will result in a coastline with bays and headlands.	
1.1.4 Processes of coastal weathering, mass movement, erosion and the characteristics and formation of associated landforms and landscapes.	Learners should be able to know and understand the subaerial processes of **coastal weathering** and **mass movement** and processes of **marine erosion**. Weathering includes **physical** disintegration by such processes as freeze-thaw, salt crystallisation, and wetting and drying. **Chemical** decomposition includes solution and carbonation. The variety of intertidal organic life encourages **biotic** weathering. Slopes in the coastal zone are subject to the downslope movement of material under the influence of gravity (mass movement). Mass movement varies according to the speed of movement and amount of lubrication of material and takes the form of **landslides**, **slumps** and **rock falls**. Marine erosional processes include **hydraulic action**, **abrasion (corrasion)**, **corrosion** and **attrition**. Processes need to be linked to the formation of at least two landforms of coastal erosion including **cliffs**, **headlands and bays**, **cave-arch-stack-stump sequence** and **wave-cut platforms**, **geos** and **blowholes for the UK and beyond the UK**.	For an outline of processes and landforms of coastal erosion see slides 38–50 and 54–72 – http://slideplayer.com/slide/1372629/ Coastal processes and features Coastal erosion BBC clips: The formation of a wave-cut platform and a stack are illustrated. How caves, arches and stacks are formed at the coastline. Aerial erosion also has a role to play in the formation of coastal features such as the Bullers of Buchan in Aberdeenshire. VIDEO – Coastal Landforms – Old Harry, Dorset.

		VIDEO – Scientists use technology to study coastal erosion http://www.bbc.co.uk/news/uk-15268984 Field sketches of cliff profiles. Annotate photographs in the field using appropriate apps such as Skitch, which helps with the labelling and annotation of photographs (see skills exercise). Rate of cliff retreat per year by rock type – Stiff, P. (2007) *Coasts.* Oxon. Philip Allan Updates. ISBN 978-1-84489-615-8 Activity 1, p.25. Geospatial technologies including aerial photographs, digital images, satellite images, geographic information systems (GIS), global positioning systems (GPS), databases – use of GIS and aerial photo interpretation to measure rates of coastal retreat http://www.arcgis.com/home/webmap/viewer.html?webmap=89f3c6777a554d01808d26b9b5856cc5&extent=-123.6961,47.9973,-123.0273,48.2599
1.1.5 Processes of coastal transport and deposition and characteristics and the formation of associated landforms and landscapes.	Learners should understand **coastal transport processes of solution**, **suspension**, **saltation** and **traction** and the movement of sediment by **longshore drift**. Deposition occurs when and where there is insufficient energy to move sediment further, and learners should understand processes of **sediment sorting** and **flocculation**. Processes need to be linked to the formation of at least two landforms of coastal	For an outline of processes and landforms of coastal deposition see slides 102–112 – http://slideplayer.com/slide/1372629/ Features formed by longshore drift are explained and illustrated. VIDEO – Growth of Pagham spit. https://www.youtube.com/watch?v=fug6fc5GqiY

	deposition including **beaches**, **spits**, **bars**, **tombolos** and **cuspate forelands for the UK and beyond the UK**.	Number and statistical calculations as applied to sample of beach pebbles (see skills exercise). Article covering coastal fieldwork on a beach www.thegeographeronline.net/uploads/2/6/6/2/26629356/gf551.pdf
1.1.6 Aeolian, fluvial and biotic processes and the characteristics and formation of landforms in coastal landscapes.	Learners should know and understand that the sea and its shoreline create conditions in which different biogeographical environments develop. Some coastal environments can be found in most parts of the world, such as **sand dunes** and **estuaries**, whereas others are restricted to tropical and subtropical areas, such as **coral reefs** and **mangrove swamps**. Coastal **sand dunes** form as a result of both wave action and aeolian processes. **Tidal flats**, **salt marshes** and **micro-features** of **channels** and **rills** develop in estuarine environments where an important process is flocculation (see 1.1.5). Coral is a polyp with the property of secreting a calcareous skeleton that remains behind when it dies. **Coral reefs** build up through time. Coral polyps can grow only in clear, mud-free water where the temperature does not fall below 22°C. **Mangroves** are a range of tree and bush species that are adapted to life in coastal swamps and estuaries in tropical waters located between mid tide and high tide marks, with pioneer species growing close to the low tide mark.	Formation of sand dunes http://www.geography-site.co.uk/pages/physical/coastal/dunes.html https://www.youtube.com/watch?v=gKU1K8n6jYM Formation of salt marshes https://geographyas.info/coasts/features-of-deposition/ Formation of coral reefs http://geography.about.com/od/waterandice/a/coralreefs.htm https://www.youtube.com/watch?v=rHF1N6B4T6Y https://www.youtube.com/watch?v=nBO7zWO1zXY

1.1.7 Variations in coastal processes, coastal landforms and landscapes over different timescales.	As well as understanding the main processes of erosion and deposition in glacial environments, it is important that learners understand the timescale over which they operate. These can vary from seconds to millennia. In any landscape there are processes which operate infrequently but at high magnitude and have an instantaneous effect, for example cliff collapse during a **storm event** altering the **cliff profile**. By contrast there are high frequency, but low magnitude processes such as the slow movement of material onshore by small constructive waves occurring predominantly in the summer, or the regular removal of sediment by destructive waves during the winter resulting in **seasonal changes in beach profiles**. It is important that learners understand that landscapes also evolve over long timescales and are required to study the impact of either eustatic changes or isostatic changes in sea level on one landform such as fjords, rias or raised beaches.	VIDEO – Coastal erosion in UK from above VIDEO – Cliff collapse: Dramatic coastal erosion on Jurassic Coast. http://www.youtube.com/watch?v=ITv6gSUmTjc VIDEO – White cliffs of Dover fall into the sea: https://www.youtube.com/watch?v=4g3uMo34rns https://www.tutor2u.net/geography/reference/gcse-geography-landforms-of-deposition-beaches-coastal-landscapes-7#:~:text=Autumn%20and%20winter%20%2D%20destructive%20waves,sand%20dunes%2C%20aided%20by%20saltation Coastlines affected by sea level change: https://www.bbc.co.uk/bitesize/topics/zqhg9j6/watch/znpd7ty This animation shows how sea level has changed in the British Isles during the last 10 000 years. http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml This interactive map provides information of locations experiencing a rise in sea level and those experiencing a fall.

1.1.8 Coastal processes are a vital context for human activity.	Learners need to know and understand that **coastal processes** can have a **positive impact** on human activity, and are required to study one example. Tourism is encouraged by beautiful and dramatic coastal scenery and/or the active leisure that can be pursued at a coastline. **Coastal processes** can also affect human activity in a **negative** way, and learners are required to study one example. Marine erosion will cause cliff collapse, often endangering buildings. Learners need to examine **one management strategy** implemented to manage the negative impacts of coastal processes on human activity.	ArcGIS - Coastal erosion and defence in England and Wales: https://www.arcgis.com/home/item.html?id=8c48721fb89a47e784fe2823c3f89bbe Villages lost to coastal erosion http://www.bbc.co.uk/news/in-pictures-22025150 VIDEO – Cliff top Devon home going cheap... But there's a catch! http://www.bbc.co.uk/news/uk-23252455 VIDEO – Battling the coastal erosion threat: https://www.youtube.com/watch?v=Iz3zqCDD3tE Coastal landforms and management Coastal management strategies Coastal management case study: Lyme Regis https://www.internetgeography.net/topics/lyme-regis-case-study-of-coastal-management/ Coastal protection methods – comparison table Bown, J. (2013) Westward Ho! A case study of coastal management. *Geography Review* 27 (2) pp.2–6
1.1.9 The impact of human activity on coastal landscape systems.	Learners should know and understand that human activity can have a **positive impact** on **coastal processes and landforms** through management and	Dune management at St. Andrews: https://jncc.gov.uk/our-work/west-sands-dune-management/

	conservation, and are required to study one example, Human activity can also affect **coastal processes and landforms** in a **negative** way, for example through offshore dredging and the erosion of sand dunes, and are required to study one example. Learners need to examine **one management strategy** implemented to manage the negative impacts of human activity on coastal processes and landforms.	Dredging report: https://www.thecrownestate.co.uk/media/3989/south-coast-physical-processes.pdf Impact of dredging at Hallsands: https://maritimearchaeologytrust.org/3407-2/

Revision resource: Arcgis story map: Coastal Landscapes

Changing Landscapes – Glaciated Landscapes

Focus	Amplification of Content	Teaching/Learning Approaches and Resources
1.2.1 The operation of a glacier as a system.	The geomorphological content of Glaciated Landscapes is specifically framed within a systems context so learners should know and understand the physical landscape as a series of linked components through which energy and material are cycled. Glaciers provide an ideal illustration of the systems approach: they are part of a broader environmental system and are associated with clear **inputs** (e.g. the accumulation of snowfall) and **outputs** (e.g. production of meltwater or the deposition of sediment). **Stores** hold the snow, ice, meltwater and debris. **Transfers** move the snow, ice, meltwater and debris through the system. Learners need to appreciate that the inputs to and outputs from a glacier are not constant, but **change** continually over both **short and long timescales**. The **glacier system** constantly adjusts to changes in the balance between accumulation and ablation and this is reflected in the **mass balance** of a glacier. If accumulation exceeds ablation a glacier gains mass (positive mass balance). If there is more ablation than accumulation a glacier has a negative mass balance. If there is a **decline in snowfall** and/or **increase of temperature**, then there will be a period of time when	Construct a diagram of the glacial system: https://www.antarcticglaciers.org/glacier-processes/mass-balance/introduction-glacier-mass-balance/ and identify inputs, outputs, stores and transfers of energy and materials. https://www.youtube.com/watch?v=D-pjVNIROzM video clip examines the changing balance of glacial advance and retreat (up to 12 min 40s). Calculation of glacier mass balance (see skills exercise) and https://calculator.academy/glacier-equation-calculator/ Retreat of the Sierra de Sangra Glaciers http://visibleearth.nasa.gov/view.php?id=87541 Identification of whether the following statements illustrate positive or negative feedback: Decreasing ice cover will mean exposed land absorbs more heat and speeds warming further (positive feedback).

	melting exceeds the input of new ice and the glacier will **lose mass** until it reaches a new **equilibrium** between accumulation and ablation. Changes in mass balance (inputs vs outputs) provide the key link between atmospheric processes and glacier extent and help explain how climate change results in a change in extent and the formation of related features such as end moraines. This clearly aligns to the specification's requirement that learners understand how landscapes evolve as a result of processes driven by past, present and future climate change. A systems approach subdivides a complex system into a series of interrelated component parts that are linked via transfers of mass and/or energy. A change in any part of the system, for example in the operation of a particular process, can lead to changes in the whole system. Sometimes these are accelerated or enhanced as the system reacts (**positive feedback**), and sometimes they are slowed down or counteracted by the system (**negative feedback**). Changes in the broader environmental system, such as climate change, can induce a change in the state of a glacier by influencing the balances between inputs, transfers and outputs.	Enlargement of initial hollow into glacial cirque with the capacity for storing and accumulating ice, resulting in increased erosion (positive feedback). Advance of glacier to lower altitudes, causing more of the glacier to lie in the ablation zone, increasing output of meltwater (negative feedback).
1.2.2 Climate change and the glacier budget over different timescales.	Learners should know and understand that glaciers have shown periods of expansion and retreat as climate changes have shifted the net balance to either positive (colder conditions) or negative (warmer	https://www.bbc.co.uk/bitesize/guides/zx234j6/revision/2 Overlap with 1.2.1 above:

	conditions). Only a brief overview of reasons for climate change over the geological timescale (Milankovitch cycle and associated **glacials**, **interglacials** and **stadial periods** and **thresholds for change**), historical timescale (Maunder Minimum and associated **Little Ice Age**) and summer and winter changes (**seasonal variations**) is required.	https://www.youtube.com/watch?v=9h-bQKiX7nQ video clip examines the changing balance of glacial advance and retreat in the Alps. Little Ice Age: https://www.science.smith.edu/climatelit/the-effects-of-the-little-ice-age/
1.2.3 Glacier movement.	Learners need to know and understand that glaciers can be classified as **cold-based** or **warm-based** depending on whether they are frozen to the underlying bedrock or not. Cold polar glaciers tend to be cold-based, but outside of the Polar Regions most glaciers are warm-based. However large glaciers can be cold-based in their upper regions and warm-based near their margins when they extend across different climatic zones. Slow rates of accumulation and ablation associated with glaciers in cold continental climates result in a smaller imbalance between the zone of accumulation and zone of ablation and slower ice movement. Glaciers in temperate-maritime climates have greater snowfall in winter and experience more rapid ablation in summer, therefore glacier ice moves more rapidly towards the ablation zone to maintain the equilibrium slope angle. Warm-based glaciers, where the ice is at a temperature close to its melting point, produce large volumes of meltwater that promote the operation of basal processes and the formation of subglacial landforms (e.g. drumlins) and glaciofluvial features (e.g. eskers).	https://www.youtube.com/watch?v=njTjfJcAsBg underneath a glacier http://www.coolgeography.co.uk/A-level/AQA/Year%2012/Cold%20environs/Systems/Glacial%20Systems.htm https://www.youtube.com/watch?v=D-pjVNIROzM video clip examines the differences between cold- and warm-based glaciers (after 12 min 40s).

	Cold-based glaciers in contrast are commonly thought to be frozen to their beds and associated with limited landscape impacts. Cold-based glaciers move mainly by **internal deformation**. These glaciers are frozen to the bed and therefore only move slowly. The ice crystals within the glacier orientate themselves in the direction of ice movement. **Movement is by the dislocation of individual** ice crystals and not of the whole body of ice. Warm-based glaciers move mainly through basal sliding. If the glacier moves, this can raise the temperature of the base ice through pressure and friction. The basal ice can then melt, and this water helps to allow the ice to slip more easily over its bed. **Subglacial bed deformation** occurs in warm-based glaciers where the weight of the ice, and therefore pressure, causes subglacial material to deform and move the overlying ice. **Surges** are periods of glacier movement as the glacier snout advances up to a thousand times faster than normal. Surges are considered to be the result of a change in the flow pattern of subglacial meltwater that are not related to climate. **Compressional flow** occurs where there is a decrease of velocity in a downglacier direction. **Extensional flow** occurs where surface glacier velocity is increasing downglacier and is responsible for the development of crevasses.	

1.2.4 The range of glacial environments and their distribution.	Learners need to know and understand that there are several different types of **ice mass**. Ice masses can be divided on the basis of their size or whether they are land-based or marine-based. They can be constrained (**cirque glaciers**, **valley glaciers**, **piedmont glaciers**) by valley sides or unconstrained (**ice sheets**, **sea ice**), in which case they flow freely over the surrounding land/sea. Regardless of their type, all ice sheets flow and can transform the landscape by erosional and depositional processes. The distribution of ice masses has changed over time and learners need to know and understand that the maximum extent of ice sheets was reached 18 000 years BP (the late Devensian), and compare the **past distribution** of ice masses with the **present-day distribution**. The European Alps is an example of a presently glaciated landscape with topographically constrained glaciers including valley glaciers and cirque glaciers. It illustrates both the present-day glacial impact on landscape and evidence of formerly more extensive glaciation. It also provides extensive evidence of ongoing glacier recession. Iceland is an example of a presently glaciated landscape with both topographically unconstrained ice caps and topographically constrained outlet glaciers. Antarctica is a presently glaciated landscape with topographically unconstrained continental ice sheet. The English Lake District and North Wales are examples of formerly glaciated landscape shaped	Glaciers online (http://www.swisseduc.ch/glaciers/) provides extensive imagery from glacial environments around the world and includes a useful photoglossary. AntarcticGlaciers.org (http://www.antarcticglaciers.org/) focuses on explaining the science of Antarctic glaciology and contains resources relating to the nature and behaviour of Antarctic glaciers and their landscape impacts. BGS Observatory at Virkisjokull, Iceland (http://www.bgs.ac.uk/research/glacierMonitoring/home.html) provides a range of resources relating to the British Geological Survey's ongoing monitoring of the recession of an outlet glacier in Iceland, including timelapse imagery and live images. BRITICE – The British Ice Sheet (https://www.sheffield.ac.uk/geography/staff/clark_chris/britice) provides access to a map and GIS database of the glacial landforms and features related to the last British Ice Sheet, useful for exploring the larger-scale landscape impact and landform assemblages created by ice sheets. All About Glaciers – National Snow and ice Data Centre (http://nsidc.org/cryosphere/glaciers) provides information about glaciers.

	primarily by topographically constrained glaciers including valley glaciers and cirque glaciers. The North American Laurentian shield is an example of a formerly glaciated landscape shaped by a continental scale ice sheet. Comparison with a formerly glaciated upland landscape (e.g. the English Lake District) demonstrates the contrasting landscape impacts of valley glaciers and ice sheets referred to in the specification.	Monitoring of changing areal extent of Swiss glaciers http://glaciology.ethz.ch/messnetz/massbalance.html Ice sheets at a range of scales – table summarising their volume and extent (see skills).
1.2.5 Processes of glacial weathering, erosion and the characteristics and formation of associated landforms and landscapes.	Learners need to know and understand the weathering and erosion processes operating in glacial environments. The relatively high humidity combined with relatively low temperatures oscillating above and below freezing make **freeze-thaw weathering** predominant: the low temperatures make chemical weathering less important. The processes of erosion can be divided into three categories: **glacial abrasion**, **plucking** and **subglacial fluvial erosion**. Learners need to know and understand the factors affecting glacial erosion including **basal thermal regime**, **ice velocity**, **ice thickness**, **bedrock permeability** and **jointing**. Processes and factors need to be linked to the formation of at least two erosional landforms including **cirques**, **pyramidal peaks**, **arêtes**, **glacial troughs**, **ribbon lakes**, **hanging valleys**, **truncated spurs**, **roches moutonees**, **crag and tail** and **striations for the UK and beyond the UK**.	www.youtube.com/watch?v=mWw0abWQe00 animation of the processes BBC clips: A highland landscape is described before, during and after glaciation The key features of a glaciated valley are described using the Lochaber area of Scotland as an example The landforms found in Loch Lomond before glaciation and the effect of glaciation on the area are discussed. Animations clearly illustrate the landforms associated with glaciation, such as truncated spurs and hanging valleys This clip explains the formation of many of the landforms associated with glaciation, e.g. corries, aretes, pyramidal peaks and truncated spurs.

		Geography Advanced Topic Masters: *Glaciation & Periglaciation*. Author: Jane Knight 144pp • 978 1 844 89617 2 OS map cross-section of Nant Ffrancon valley p.36 (see skills exercise). Field sketches of glacial landforms of erosion. Annotate photographs in the field using appropriate apps such as Skitch, which helps with the labelling and annotation of photographs (see skills exercise).
1.2.6 Processes of glacial and fluvioglacial transport, glacial and fluvioglacial deposition and the characteristics and formation of associated landforms and landscapes.	Learners need to know and understand that transported glacial material can be classified as either **supraglacial, englacial** or **subglacial** debris. Subglacial debris is most altered during transport. Sediments transported by meltwater are distinct from sediments transported by ice. Fluvioglacial transport involves more rounding of sediments through attrition and abrasion and more sorting. Learners need to appreciate that the processes by which glaciers deposit material are complex. Ablation results in **ablation** till, **lodgement** results in lodgement till and **deformation** till forms by the deformation of weak rock or pre-existing till by the pressures exerted by moving ice. Learners need to recognise and understand the formation of landforms of glacial deposition including subglacially formed moraines	See http://www.coolgeography.co.uk/A-level/AQA/Year%2012/Cold%20environs/Fluvioglacial/Fluvioglacial%20landforms.htm for the formation of sandur, eskers, kames and kame terraces. http://www.geography-site.co.uk/pages/physical/glaciers/deposit.html glacial deposition and depositional landforms https://www.youtube.com/watch?v=677PQitX7Fk drumlin formation Number and statistical calculations as applied to sample of glacial clasts (see skills exercise).

	such as **drumlins** and at least one ice-marginal moraine such as **terminal**, **recessional**, **lateral** or **push moraines**. In periods of higher temperature when ice and snowmelt occurs, fluvioglacial transport and deposition leads to the formation of ice-contact features and proglacial features. Processes need to be linked to the formation of at least one ice-contact feature including **eskers**, **kames** and **kame terraces** and at least one proglacial feature including **sandurs**, **varves**, **kettle holes** and **kettle lakes for the UK and beyond the UK**.	
1.2.7 Periglacial processes and the formation of associated features and landscapes.	Learners need to know and understand periglacial processes and the formation of associated features. An important process in periglacial areas is frost heave. This results from ice crystals or ice lenses forming in fine-grained soils. As the ice expands, the ground above is domed up and stones get pushed to the surface. On areas of low relief important periglacial processes are frost heaving and thrusting, and associated periglacial landforms **are ice lenses**, **ice wedge polygons**, **patterned ground**, **pingos** and **thermokarst landscape**. **Frost weathering** and **mass movement** produces **nivation hollows**, **blockfields**, **scree slopes** and **pro-talus ramparts**, but higher temperatures in summer may lead to solifluction, an important but slow mass movement process contributing to **solifluction terraces** and **head deposits**.	http://www.physicalgeography.net/fundamentals/10ag.html periglacial processes and landforms https://www.youtube.com/watch?v=oyclzdKVoDI ice wedge formation https://www.youtube.com/watch?v=qZsHUcwEc3whttps://www.youtube.com/watch?v=qZsHUcwEc3w Ice wedges in Alaska's National Parks https://www.youtube.com/watch?v=4_mVhXYc7W4 Pingos in Alaska's National Parks https://www.youtube.com/watch?v=KNQiyGNhT5Ihttps://www.youtube.com/watch?v=KNQiyGNhT5I Pingo formation – open system and closed system

	Periglacial action by **water** results in **dry valleys**, and periglacial action by **wind** results in **loess plateaux**. Learners should be able to identify and differentiate between the landscapes created by **valley glaciers** and **ice sheets**. This is important as these different categories of glacier produce different landscapes. Glaciated valley landscapes are typically dominated by erosional features such as cirques and U-shaped valleys (see 1.2.5), whilst landscapes affected by ice sheets commonly include features such as extensive drumlin fields and outwash plains (see 1.2.6). A consideration of either situation provides the opportunity to consider the specific types and distinctive spatial arrangement of landforms associated with these different types of ice mass.	http://www.bbc.co.uk/learningzone/clips/gorges-and-dry-valleys/4708.html Dry valley formation BRITICE – The British Ice Sheet (https://www.sheffield.ac.uk/geography/staff/clark_chris/britice) provides access to a map and GIS database of the glacial landforms and features related to the last British Ice Sheet, useful for exploring the larger-scale landscape impact and landform assemblages created by ice sheets. Geoactive Online article on landforms of lowland glaciation in the UK can be found at: http://bishopshums.wikispaces.com/file/view/ga277.pdf Classification of glacial landscapes according to landscape character type. Comparisons of characteristics of glacial environments using GIS mapping of the variety of glacial (highland and lowland) landscapes both for and beyond the UK (see skills exercise). Benn, D. and Evans, D.J.A. (2010) *Glaciers and Glaciation* (2nd Ed.) Hodder Arnold. ISBN: 978-0340905791 This is a compendious textbook covering this whole area in great detail. Intended primarily as a university undergraduate text, this is a good general resource

		and reference, but includes much more detailed information than is required at A level.
1.2.8 Variations in glacial processes, glacial landforms and landscapes over different timescales.	As well as understanding the main processes of erosion and deposition in coastal environments, it is important that learners understand the timescale over which they operate. These can vary from seconds to millennia. In any landscape there are processes which operate infrequently but at high magnitude and have an instantaneous effect, for example **rapid mass movement** processes causing changes in **glacial valley profiles**. By contrast there are landforms associated with **seasonal variations** in fluvioglacial transport and deposition. In the formation of **varves**, the coarser sediment is deposited in summer when meltwater is abundant and stream transport is active; the finer sediment settles out slowly during the winter (see 1.2.6). It is important that learners understand that landscapes also evolve over long timescales and that they are required to study the impact of postglacial reworking of glacial deposits. Relevant geomorphological processes include mass movement processes (modifying valley profiles largely created by glacial erosion), fluvial processes (resulting in the infilling at the head of ribbon lakes), or weathering processes (breaking down glacial and fluvioglacial	https://www.youtube.com/watch?v=N5fLWD3wdK8 Varve formation

	deposits). Processes need to be linked to the formation of at least two landforms. Since the last glaciation, the change to milder humid temperate conditions, together with changes in base level due to isostatic adjustment, have significantly modified glacial landforms.	
1.2.9 Glacial processes are a vital context for human activity.	Learners need to know and understand that glacial processes and landforms have a major impact on people's lives, for example, **glacial lake outburst floods** are a major hazard in mountainous areas such as the Himalayas. Human activity can also have an impact on glacial processes or landforms, for example the **extraction of sands and gravels** from fluvioglacial deposits and the **construction of reservoirs**. Learners need to examine **one management strategy** used to manage either the impact of glacial processes or landforms on human activity such as glacial lake outburst floods, or to manage the impacts of human activity on glacial processes or landforms such as reservoir construction? Learners also need to know and understand that conventional construction techniques used in periglacial environments alter the thermal balance of the ground leading to permafrost thaw and ground subsidence. Vegetation clearance reduces the insulation of the permafrost, resulting in the deepening of the active layer in summer as heat is transferred to the permafrost table more easily,	http://glacierhub.org/ Provides information about current scientific research, tells stories of people who live near glaciers or who visit them, and offers accounts of the efforts of communities and organizations to address the challenges brought by glacier retreat. https://www.youtube.com/watch?v=2Itb2K6oTgo&list=PLcayrWRIfU0cxTapM-sTfMuIri9zxDSpz&index=14 A short discussion of glacial lake outburst floods (GLOFs) in Manaslu Conservation Area, Nepal. http://glofs-database.org/glofs http://glaciers.uoregon.edu/hazards.html https://www.youtube.com/watch?v=6C_TGDhc3t0 Mark Carey explains GLOFs at 4000 meters above sea level in the Quebrada Honda of Peru's Cordillera Blanca mountains. https://www.youtube.com/watch?v=BexXgQakves#t=13 Bhutan – Silent tsunami.

	speeding up the development of a thermokarst landscape beyond the natural rate.	

Additional resource links can also be viewed here

Tectonic Hazards

Focus	Amplification of Content	Teaching/Learning Approaches and Resources
1.3.1 Tectonic processes.	An overview of the Earth's internal structure should be given so that learners have a context in which to place tectonic processes. Learners should understand the layered structure of the earth (inner core, outer core, mantle, including the asthenosphere, and crust) and have knowledge of the significant boundaries (Lehmann discontinuity between inner and outer core, Gutenberg discontinuity between outer core and mantle and Mohorovicic discontinuity between mantle and crust). Learners should have a knowledge of the physical characteristics (thickness, composition and physical behaviour) of each layer. Candidates should recognise the difference between oceanic and continental crust. The mechanisms that generate movement of tectonic plates should be understood. This could start with internal heating and lead to convection currents, ridge push and slab pull. The mechanics of plate movement can be linked to the processes operating at different margins: diverging, converging (ocean/ocean, ocean/continental and continental/continental) and conservative. These processes can also be applied to hot spots. Note that as the unit is about hazards, the focus is on the process rather than the production of specific landforms other than volcanoes.	http://www.burkemuseum.org/geo_history_wa/The%20Restless%20Earth%20v.2.0.htm – Earth structure and processes http://www.tulane.edu/~sanelson/eens1110/ –lecture notes of Tulane University Annotate a cross-section of the Earth. http://openhighschoolcourses.org/mod/book/tool/print/index.php?id=6645#ch2989 text and audio http://dlblanc.com/earth/tectonic/mechansm.php –for teachers http://www.geolsoc.org.uk/Plate-Tectonics/Chap3-Plate-Margins/Mid-plate/Hawaiian-Islands – good explanations and visuals http://www.pbslearningmedia.org/resource/9a60ceac-7574-4a2c-ba64-e45e8035f4e6/life-on-fire-hot-spots/

1.3.2 Tectonic hazards.	The impact of tectonic hazards is partially dependent on the physical characteristics of earthquakes and volcanoes. Learners should know that earthquakes and volcanoes vary in magnitude – Mercalli and Richter scales for earthquakes, and Volcanic Explosively Index for volcanoes. The hazard profile of earthquakes and volcanoes can also be characterised by: • predictability – the probability of an event occurring over time and space • the frequency – the return interval of events of of a certain size using the idea that the larger the event the less frequently it occurs • duration – the length of time that a hazard exists using the concept that the longer the hazard the severe it is likely to be • the speed of onset – the time difference between the start of the event and its peak • areal extent – the size of the area covered by the hazard.	http://www.pbslearningmedia.org/resource/ess05.sci.ess.earthsys.tectonic/tectonic-plates-earthquakes-and-volcanoes/ http://www.iris.edu/hq/inclass/fact-sheet/why_do_earthquakes_happen http://www.decodedscience.org/the-pacific-ring-of-fire-source-of-major-earthquakes-and-volcanic-activity/26828 – the ring of fire case study http://www.iris.edu/hq/inclass/fact-sheet/how_often_do_earthquakes_occur
1.3.3 Volcanoes, processes and hazards.	Learners should have a knowledge and understanding of the characteristics of the major types of volcano including shield, composite and cinder. Differences in shape, structure and composition can be identified. These characteristics can be related to the nature of different volcanic eruption types. Particular reference can be made to explosive and effusive eruptions. The type of volcano and eruption type can be related to tectonic situation.	http://www.tulane.edu/~sanelson/Natural_Disasters/volclandforms.htm http://www.bgs.ac.uk/discoveringGeology/hazards/volcanoes/eruptions.html https://laulima.hawaii.edu/access/content/group/2c084cc1-8f08-442b-80e8-ed89faa22c33/book/chapter10/volcanoes.htm

	Volcanic processes lead to the production of particular hazards and these can often be related to the type of volcano: • pyroclastic flows – superheated clouds of ash, gas and small tephra that travel at high speeds • lava flows – rivers of molten rock that pour from an erupting vent • ash fall – fragments of rock produced when magma or rock is ejected during an explosive eruption • lahars – a mixture of water and rock fragments that flows down the slopes of a volcano • jökulhlaups – sudden discharge of glacial meltwater • volcanic landslides – large masses of debris that move rapidly down the slopes of a volcano and are triggered by a variety of processes • toxic gases – gases within the magma that are released when it rises to the surface and pressure is released.	https://www.youtube.com/watch?v=WBADmZSakAk – volcanoes around the world https://www.youtube.com/watch?v=3Bm1L3iGnEU – effusive eruptions visuals https://www.youtube.com/watch?v=EupnfA-PDaw&list=PLkTSXWtpqL230x1i3quAeNqiDUtUfPAAs&index=2 – explosive eruptions http://pubs.usgs.gov/fs/fs002-97/ – volcanic hazards http://volcanoes.usgs.gov/vhp/hazards.html – hazards processes and impacts http://www.decodedscience.org/jokulhlaups-glacial-flash-floods-release-meltwater/49179 - jökulhlaups formation

1.3.4 Volcanoes and their impacts.	Learners must study examples in contrasting contexts to illustrate the risks and impacts of volcanic activity. The contexts chosen by centres could cover volcanic activity in a number of situations such as contrasting levels of development, contrasting populations, contrasting types of volcano, etc. When studying the examples, there is an opportunity to incorporate material from 1.3.5 to provide this focus box with a context. The study of each example should be organised so that impacts can be discussed using a number of categories. The presence and importance of these categories will vary with the examples chosen but can be seen as: • demographic – mortality, migration, population structure changes • economic – costs of losses • social – health, infrastructure, families • environmental – biosphere, lithosphere hydrosphere, atmosphere. These impacts can be (i) primary in that they are the immediate and direct consequence of the event, or (ii) secondary in that they are indirect consequences of the event. The areal scale of the impact can be local (in the immediate vicinity of the event), regional (at a broader scale that can range in scale according to the event studied) or global (at a worldwide scale).	

	It is recognised that detailed exemplar material for volcanic events may not fall within the last two decades but they should not be historic in character.	
1.3.5 Earthquakes, processes and hazards.	Learners should have a knowledge and understanding of the mechanisms that lead to earthquake events. The main characteristics of earthquake events should be understood, including: • focus – the point within the earth at which the earthquake originates • depth of focus – shallow, intermediate and deep focus • epicentre – the point on the earth's surface vertically above the focus. Learners should understand the character of P and S waves and how they are generated by earthquakes. Earthquakes, and the associated wave movements, produce a number of hazards including: • ground shaking – the vibration of the earth during an earthquake caused by seismic waves • liquefaction – the way in which the soil liquifies during an earthquake. The water separates from the soil particles and rises to the surface • landslides – on steep slopes the vibration caused by earthquakes can trigger landslides and mudflows (sometimes linked to liquefaction) • tsunamis – earthquakes which cause the bodily displacement of large volumes of water by movement of the sea floor.	http://cse.ssl.berkeley.edu/lessons/indiv/davis/inprogress/QuakesEng3.html – definitions and diagrams http://web.ics.purdue.edu/~braile/edumod/waves/WaveDemo.htm#P_S_R_L_Animations – animations of different waves http://www.slideshare.net/tudorgeog/341-earthquake-hazards-1063365 – ppt http://www.sms-tsunami-warning.com/pages/seismic-waves#.VtwgIrzPwSI – overview

1.3.6 Earthquakes and tsunamis and their impacts.	Learners must study examples of at least two contrasting contexts of the risk and impacts of seismic activity. The contexts chosen by centres could cover earthquakes in a number of situations such as contrasting levels of development, contrasting populations, depth of focus, etc. When studying the examples, there is an opportunity to incorporate material from 3.1.5 to provide this focus box with a context. The study of each example should be organised so that impacts can be discussed using a number of categories. The presence and importance of these categories will vary with the examples chosen but can be seen as: • demographic – mortality, migration, population structure changes • economic – costs of losses • social – health, infrastructure, families • environmental – biosphere, lithosphere. These impacts can be (i) primary in that they are the immediate and direct consequence of the event, or (ii) secondary in that they are indirect consequences of the event. The areal scale of the impact can be local (in the immediate vicinity of the event), regional (at a broader scale that can range in scale according to the event studied) or global (at a worldwide scale).	https://geogabout.wordpress.com/2015/04/25/nepal-earthquake-2015/ – Nepal http://geogabout.blogspot.co.uk/search/label/Japan%20earthquake%202011 – Sendai http://slideplayer.com/slide/6965720/ – structured ppt to organise comparison of two earthquakes

1.3.7 Human factors affecting risk and vulnerability.	Learners should understand the difference between risk (the probability of a hazard event causing harmful consequences), and vulnerability (the geographic conditions that affect the susceptibility of a community to a hazard or the impacts of a hazard). There are a number of factors affecting the risk and vulnerability of a place or community to tectonic hazards: • Economic factors that can be related to the wealth of the place or community. This is linked to both the level of development and technology. Where wealth and technology is present, impacts can be managed by responses such as preparation, prediction and mitigation. • Social factors such as the population density where more people are at risk in densely populated areas. Population structures can contain high proportions of age and gender groups that are susceptible to hazards. Public education can reduce the vulnerability by empowering and making the population more adaptive. • Political factors such as good governance and preparation of emergency services can reduce the vulnerability of a population. • Geographical factors associated with the location of the tectonic event can impact upon	

	vulnerability. The populations and facilities associated with urban and rural environments can affect vulnerability. The time of day will affect the exposure of a population, as this will impact on the number of people in circulation. Isolation will impact on access for emergency services. These factors can be examined with a theoretical focus but can also be seen in the context of the examples used to illustrate the impacts of volcanoes and earthquakes. In this form, they will have variable application and each case study need not cover all factors nor have equal application.	
1.3.8 Responses to volcanic hazards.	Strategies used to manage volcanic hazards can be divided into those that attempt to predict and warn populations about the event, those that attempt to mitigate the impacts of the event, and those that respond to the event. Monitoring, prediction and warnings take a number of forms. Learners should be aware these have a varying degree of accuracy and effectiveness. Techniques of mitigation take a variety of forms according to the event and wealth of the country. These include building design, home preparedness, physical defences, evacuation, land use control, preparation of emergency services, etc. Strategies that respond to the event can be divided into short and long-term responses. These can be defined as rescue, followed by rehabilitation, followed	

	by reconstruction. The hazard management cycle offers a way of organising responses. The range of responses used to manage volcanic hazards can be studied in the context of the examples used to illustrate the impact of volcanoes. An exhaustive study of all responses is not required.	
1.3.9 Responses to earthquakes and tsunamis.	Strategies used to manage earthquake and tsunami hazards can be divided into those that attempt to predict and warn populations about the event, those that attempt to mitigate the impacts of the event, and those that respond to the event. Monitoring, prediction and warnings take a number of forms depending on the earthquake and tsunami hazard. Learners should be aware these have a varying degree of accuracy and effectiveness. Techniques of mitigation take a variety of forms according to the event and wealth of the country. These include building design, home preparedness, physical defences, evacuation, land use control, preparation of emergency services, etc. Strategies that respond to the event can be divided into short and long-term responses. These can be defined as rescue, followed by rehabilitation, followed by reconstruction. The hazard management cycle offers a way of organising responses. The range of responses used to manage earthquake and tsunami hazards can be studied in the context of the examples used to illustrate the impact of earthquakes and tsunamis. An exhaustive study of all responses is not required.	http://news.bbc.co.uk/1/hi/world/south_asia/6197766.stm – tsunami warning http://www.gfdrr.org/sites/gfdrr/files/publication/GFDRR_Haiti_Reconstruction_KnowledgeNotes_0.pdf – reconstructing Haiti

Additional resource links can also be viewed here

Changing Places

Focus	Amplification of Content	Teaching/Learning Approaches and Resources
2.1.1 Changing place; changing places – relationships and connections.	The objective of this section is to introduce learners to the concept of place (a portion of geographic space to which meaning has been given by people), and the relationships and connections between places. Place can be understood at a range of scales. It is expected that learners use their 'home' place as a starting point to studying place and compare this with at least one further contrasting place. A local place can be understood as a locality, neighbourhood or a small community. Learners should know and understand that the demographic, socio-economic and cultural characteristics of places are shaped by factors including shifting flows of people, resources, money and investment. Places change over time and develop layered history. This history helps to shape the identity and 'personality' of a place. The identity is also shaped by the relationship to other places at a range of scales. A place may symbolise different things for different people. Learners should explore how demographic characteristics, such as the components of population, change (natural fertility, mortality and age/sex structures) and vary within and between	Place is a portion of geographic space to which meaning has been given by people. Describe how the 'home' place – a locality, neighbourhood or small community such as Salford Quays is formally/statistically represented using maps (graphical) and statistical data sources: • http://www.ons.gov.uk/ons/index.html to describe census data such as population, gender, age structures and level of education. • http://www.ukcrimestats.com or http://www.crime-statistics.co.uk to describe crime types and levels. • http://dclgapps.communities.gov.uk/imd/idmap.html to describe deprivation data and http://www.localhealth.org.uk to describe health data. http://home.rm.com/schoolfinder/ to describe school types and standards quality. • http://www.rightmove.co.uk or http://www.zoopla.co.uk to describe house types, prices and availability, and question why certain streets are so expensive. http://www.theguardian.com/money/2015/dec/

	places and with time. Learners should acquire an understanding of how processes such as globalisation, seen by the actions of MNC fast food chains, impact on the characteristics of places (operating at different scales from local to global), learners' own lives and the lives of others.	11/victoria-road-in-kensington-is-most-expensive-street-in-england-and-wales • http://londonspovertyprofile.org.uk Mapping inequality within urban areas: London's Poverty Profile and read Danny Dorling (2013) *The 32 Stops*. London: Penguin Books to explore the extent and impact of inequality in London. Learners can make field visits and create a place audit/profile by using: http://www.rgs.org/OurWork/Schools/Fieldwork+and+local+learning/Local+learning/Fieldwork+in+the+local+area/Place+profiling.htm Read the article Smyth, F. (2016) 'Representations of Place', *Geography Review*. 29 (4) Hodder Education. Working in pairs or small groups, learners make a presentation to the rest of the class about their chosen locality. It could be the local high street, village or small area of a town, and include information about the history of the place, the changing demographic, socio-economic and cultural characteristics of the place, and the flows and connections between people, resources, money and investment, and ideas. Places change over time and develop layered history. Use the following Curriculum Press factsheet to

		understand how the past helps to shape places like Manchester or OUP's Geofile on Liverpool. • *Geography Factsheet 267,* 'The Changing fortunes of Manchester: An Aspiring Second City', Curriculum Press, to find out more about the history of the 'Cottonopolis'. • *Geofile 748* (Series 34, Issue 2) 'Liverpool – a comparison of demographics', Oxford University Press, to compare the health, housing, income, employment and education of Toxteth and Calderstones. Each learner or group of learners can research the process and impact of studentification or migration in a particular town/city by using: • https://www.youtube.com/watch?v=oC3LLbXRyYo&feature=related a clip showing the process of studentification and how it shapes university towns/cities such as Swansea • Smith, D., Sage, J. & Balsdon, S. (2014) The geographies of studentification: 'here, there and everywhere'? *Geography,* 99 (3), pp.116–127. Article on the geography of studentification. • https://www.youtube.com/watch?v=gNg51DSefeo and https://www.youtube.com/watch?v=Kx754CkDI1

		s showing how migration affects towns such as Redcar, Cleveland and Watford. • https://www.youtube.com/watch?v=0BHnzEJUte8 and https://www.youtube.com/watch?v=dINbQGgVEN8 showing how foreign direct investment is changing the skyline of London. • https://www.youtube.com/watch?v=Fxa0UDeU7t0 showing how places like Dubai are rapidly changing and the causes, patterns and consequences of migration. • Johnston, R., Poulson, M. & Forrest, J. (2014) 'The changing ethnic composition or urban neighbourhoods in England and Wales, 2001–2011: creating nations of strangers?' *Geography*, 99 (2), pp.67–74. • *Geofile 716* (Series 32, Issue 3) 'The Effect of Globalisation on Population Movements'. This discusses globalisation, migration and refers to Mexico. • http://21stcenturychallenges.org/2016/01/28/europes-migration-crisis/ A debate about how Europe's migration crisis is affecting the UK (21st Century Challenges, RGS-IBG) and http://21stcenturychallenges.org/2015/12/01/integrated-britain/ a discussion on Integrated Britain (21st Century Challenges, RGS-IBG).

2.1.2 Changing place; changing places – meaning and representation.	Learners should understand that places are given meaning as a result of people's perceptions, engagement with and their attachment to the place. The geographer Yi-Fu Tuan called this people-place bond 'a sense of place'. As places cannot speak for themselves and are socially constructed, learners should understand that places mean different things to different people. Places can evoke feelings of nostalgia, pride, hope, adventure, tranquillity or fear. Individuals have a unique view of place developed from their individual identity, perspective and prior experiences, mediated by their socio-cultural positioning (such as gender, ethnic origin, socio-economic grouping, race, religion). Learners should consider that places are represented in a variety of different forms both formally (statistical, geospatial and census data) and informally (popular images shown in photography, film, music, art, literature and poetry), and that there are contrasting images portrayed by and between formal and informal representations of place.	Places are given meaning as a result of peoples' perceptions, identity and experiences. Identify a variety of types of people who might be found in rural areas (farmer, newcomer, established resident), and examine their views of what 'rural' means to them. Do the same for urban areas. Explore the different perspectives people have about place by using: • https://www.youtube.com/watch?v=Fcnm9Ie_Tz8 Locals discussing the London Riots and https://www.youtube.com/watch?v=nEdJHAnG_ug Gentrification in Bethnal Green. • http://www.westcumbriamrws.org.uk/documents/340-Final_Report_of_the_Baseline_Perceptions_of_Cumbria,_the_Lake_District_and_its_Brands_(as_part_of_the_Brand_Management_Work)_February_2013.pdf Report on perceptions of the Lake District. • http://www.independent.co.uk/voices/comment/the-british-countryside-is-dying-but-do-we-want-to-save-it-a6854101.html • https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=6&ved=0ahUKEwiEzaj03ZDLAhUBkRQKHVnxA1AQFgg7MAU&url=http%3A%2F%2Fwww.arthurrankcentre.org.uk%2Flfirc%2Fitem%2Fdownload%2F1559&usg=AFQjCN

		EOlyxRQswRRTfW0aoLPLZMc6PHQ&sig2=gEUIbxGEahdKrjaUonlnnA&bvm=bv.114733917,d.d24&cad=rja • The British countryside, extracts from Hill, M. (2003) *Rural Settlement and The Urban Impact on the Countryside.* Hodder and Stoughton. • Valentine, G. (2013) 'Living with difference: proximity and encounter in urban life', *Geography*, 98 (1) pp.4–9. Class discussion – why do we all have different perceptions of places? Interview different groups of people about issues in your local area. Use local headline news stories as stimulus material. Read Chapter 5 of Oakes, S., Owen, A. and Rawlings Smith, E. (2016) *Changing Places* Sheffield: Geographical Association for ideas about how to set up an interview. Think critically and investigate what is meant by a rural and urban sense of place by using: • http://www.rgs.org/OurWork/Schools/Teaching+resources/Key+Stage+5+resources/21st+Century+Challenges/Escape+to+the+city.htm RGS schools resources. • http://www.mappiness.org.uk Get involved in the LSE Happiness Across Space project.

		Look for informal representations of places to compare with formal representations above, using a wider range of resources including: • Historical sources http://www.visionofbritain.org.uk • Social media such as https://www.pinterest.com and https://twitter.com to link to other representations (such as TV, film, advertisements, photography, art and music) • More diverse data such as the London Sound Survey http://www.soundsurvey.org.uk, Sounds of our shores http://www.bl.uk/sounds-of-our-shores and Smellscapes http://researchswinger.org/smellymaps/ Interactive map or book Henshaw, V. (2014) *Urban Smellscapes* Oxon: Routledge. Develop definitions for the key concepts (place, identity, attachment, meanings, inequality, formal and informal representations).
2.1.3 Changes over time in the economic characteristics of places.	Learners need to understand how economic change in places over time can lead to structural changes in employment as shown by the Clark Fisher Model. They should know and understand the Clark Fisher Model, the application of the model to specific	Learners to explore the three/four stages of the Clark Fisher Model and identify examples of countries which are at each stage of the model. Suggest reasons for the decline in the primary sector and later the secondary sector in the UK by using:

	countries at different stages of economic development, as well as the limitations of the model. Learners should obtain knowledge of examples of external forces and factors that influence economic restructuring including changing technology and lifestyles, government strategy and globalisation. They should also obtain knowledge of examples of the decline in primary employment in rural areas and in secondary employment in urban places, using the home area where possible. The actual content of learning will vary greatly according to examples studied. The decline in primary employment in rural areas may be attributable to the depletion of resources, cheap imports, mechanisation, social change and the value given to primary industry. The decline in secondary employment in urban places may relate to cheaper production and the growth of the secondary sector in other economies, globalisation, mechanisation and changing government attitudes and policies.	https://geographyiseasy.wordpress.com/2014/02/19/gcse-revision-economic-change/ Explain reasons for the decline in the primary sector in the UK: • http://www.hulldailymail.co.uk/TIDE-TURNING-FORGOTTEN-CITY-DOCKLAND/story-26773787-detail/story.html fishing. • http://www.economicshelp.org/blog/6498/uncategorized/the-decline-of-the-uk-coal-industry/ coal industry. • http://www.cornishman.co.uk/Granite-s-form-ndash-china-clay-ndash-led/story-23072102-detail/story.html china clay. Learners divide a piece of paper into four columns, one for each stage of the Clark Fisher Model and in each column draw a pie chart to show the employment structure for a country at that stage. Include details of the country's key industries by using: https://www.cia.gov/library/publications/the-world-factbook/ Opportunity for learners to visit a local industrial museum including the Museum of Science and Industry in Manchester, the Ironbridge Gorge near Telford; Quarry Bank Mill at Styal near Stockport

		Cheshire, the Open Air Museum at Beamish Northumberland, the National Railway Museum at York and the Piece Hall Museum in Halifax West Yorkshire.

2.1.4 Economic change and social inequalities in deindustrialised urban places.	Learners should have an awareness of the consequences of the loss of secondary industries in urban areas including unemployment, and the consequences of the loss of traditional industries in urban areas including the cycle of deprivation, social exclusion, and lower pollution levels. The loss of industry is not always evenly felt across a place or region, so learners should be aware of the groups of people who are affected and the resulting social inequalities. Learners should show knowledge of a range of government policies introduced in an attempt to improve the economy of deindustrialised places including retraining, economic (local to global), environmental policies and stimulating tertiary growth and investment by foreign MNCs. This list is not exhaustive and the use of exemplar material may touch on others.	Outline the consequences of the loss of traditional industries in urban areas by using: • https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/283885/ep9-shift-to-high-value-manufacturing-implications.pdf Fothergill, S. & Gore, T. (2013) *The implications for employment of the shift to high-value manufacturing*. Government Report focused on UK manufacturing decline, consequence for workers and implications for public policy. • http://www.theguardian.com/business/2015/oct/27/life-after-steel-redcar-future-consett Consequences of the steelworks closed in Consett. • http://www.bbc.co.uk/education/clips/zpv987h Ship building in Hartlepool and the Tyne http://www.bbc.co.uk/education/clips/zxws34j • https://www.liverpool.ac.uk/media/livacuk/publicpolicypractice/TCPA,CHAPE,&,WRAY,Closing,the,Gap.pdf The North-South divide.

		• http://www.economicshelp.org/blog/14337/environment/environmental-kuznets-curve/ and http://faculty.georgetown.edu/aml6/pdfs&zips/PalgraveEKC.pdf Environmental Kuznets curves. • http://www.theguardian.com/cities/2015/feb/04/manchester-morrissey-the-smiths This charming Manchester: is Morrissey's city still recognisable today? • https://www.youtube.com/watch?time_continue=7&v=pk7T0Ghdfso and https://www.youtube.com/watch?v=-84iahOnktI Danny Dorling discussing the persistence of growing inequalities in the UK and rising inequality in Bristol, other similar resources are available on his website http://www.dannydorling.org/ • *Geofile Online 412* (Series 20, Issue 2) 'Urban and Rural deprivation in the UK'. Read and answer the three focus questions. Compare Figure 4 and 5 with Census 2011 maps of index of deprivation and standard mortality ratios for London, and describe how they have changed over the 20year period. • *Geofile 689* (Series 31, Issue 3) 'Poverty and health – the impact of inequality'. • *Geofile 695* (Series 32, Issue 1) 'Housing supply crisis in the UK'. • *Geofile 697* (Series 32, Issue 1) 'Links Between Economic Development and Social Inequalities'.

		• http://www.ippr.org/publications/the-state-of-the-north-2015 How will we know whether the 'northern powerhouse' is working? IPPR North's annual State of the North report (2015). • https://www.jrf.org.uk/report/understanding-likely-poverty-impacts-extension-right-buy-housing-association-tenants Impact of the 'Right to Buy', Joseph Rowntree Foundation Report. Outline the consequences of the loss of traditional industries in rural areas by using: • http://www.independent.co.uk/news/uk/this-britain/the-lost-villages-of-britain-can-our-rural-communities-survive-in-the-21st-century-1788478.html Article asking 'Can our rural communities survive in the 21st century?' • http://www.ncl.ac.uk/cre/news/NU%20CRE%20Rural%20Policy%20(web).pdf Newcastle University Report 'Reimagining the rural: What's missing in UK rural policy?' Suggest reasons for the dramatic growth of the tertiary sector (tourism) in countries such as Kenya and the Dominican Republic, and read about Kenya to understand why having an economy dependent on tourism can be a problem, by using:

		https://www.cia.gov/library/publications/the-world-factbook/ and http://www.telegraph.co.uk/news/worldnews/africaandindianocean/kenya/10328465/Nairobi-attack-The-Kenya-that-wont-be-cowed.html

2.1.5 The service (tertiary) economy and the 21st Century knowledge economy (quaternary) and its social and economic impacts.	Learners should gain an understanding of the changing activities occurring in some central urban areas to include retailing, commercial and entertainment change, and their demographic and economic drivers including income change and technological change. Since the specification was first published in 2016, some urban areas have experienced growth while others have declined. The impact of the Covid 19 pandemic exacerbated trends or brought about significant changes in some areas. Learners should know that some central urban places experiencing re-urbanisation also experience the process of gentrification and associated social changes; this process has both positive and negative effects on the local community. Learners should understand how gentrification is changing the socio-economic characteristics of places over time as property prices rise, displacing lower-income families and small businesses. Learners should examine the complexity of the changing service economy including the continuing	Many large urban areas are being redeveloped with a mix of land uses including 'flagship' spaces for leisure and tourism. Learners can investigate cities such as Aberdeen, Birmingham, Cardiff, Liverpool, Paisley and Rio, by using: • http://aberdeeninspired.com Aberdeen Inspired. • http://bigcityplan.birmingham.gov.uk Birmingham Big City Plan. • https://www.cardiff.gov.uk/ENG/resident/Planning/Local-Development-Plan/Examination/Pages/default.aspx Cardiff Local Development Plan. • http://www.liverpoolvision.co.uk Liverpool Vision. • http://www.paisley2020.org/updates.htm Paisley 2020. • *Geofile 737* (Series 33, Issue 3) 'The Rio de Janeiro Olympic Games – curse or blessing?',

	decline for some central urban places, out-of-town retailing and office-parks, internet shopping and central entertainment and the impacts of these changes on people's lives at a range of scales. Learners need to know the range of services clusters found in the quaternary sector or knowledge economy including education, research, culture/creative industries, digital/IT companies, science and biotechnology. It is useful for learners to know specific examples of service clusters so as to understand the locational factors that encourage cluster growth, including proximity to universities and research institutes, government support, planning regulations and infrastructure. Learners should also understand what the impacts of quaternary industry clusters are on people and places, including place making and marketing, demographic change and global connectivity.	Oxford University Press. Will the games reduce inequalities in Rio? Learners can debate whether controversial regeneration projects should get the go-ahead. Examples include: • http://www.liverpoolwaters.co.uk £6 billion Liverpool Waters project which would alter the historic waterfront and possibly lose Liverpool its UNESCO World Heritage status. Project vision: https://www.youtube.com/watch?v=GSrcmermOqE and *Geofile 732* (Series 33, Issue 2) 'World Heritage Status – is it beneficial?', Oxford University Press. • http://www.paisley2021.co.uk Paisley's bid for UK City of Culture in 2021. • http://www.theguardian.com/business/2015/feb/14/battersea-nine-elms-property-development-housing Sovereign Wealth Funds/foreign investments in London. Gentrification and associated social changes in central urban places can be explored in places such as London and Berlin. The Guardian newspaper has a series of articles on gentrification including the following:

		• https://www.youtube.com/watch?v=gMz1x5_yF2Q Loretta Lees TEDxBrixton. • http://www.theguardian.com/cities/2016/jan/12/gentrification-argument-protest-backlash-urban-generation-displacement Victims and beneficiaries. • http://www.theguardian.com/cities/2016/feb/12/rootless-ruled-by-landlord-class-future-young-adults-cities-home-ownership Permanent renters. • http://www.theguardian.com/cities/2016/jan/28/hackney-creatives-priced-out-london-studios-artists-gentrification Creative people priced out of Hackney. Learners should understand the process of urban decline and could apply this to the example of Dudley. Start by drawing a cycle of urban decline using: http://www.coolgeography.co.uk/A-level/AQA/Year%2013/World%20Cities/Decline/Urban_Decline.htm Then read Weaver, R. & Holtkamp, C. (2015) 'Geographical Approaches to Understanding Urban Decline: From Evolutionary Theory to Political Economy…and Back?', *Geography Compass*, 9 (5) pp.286–302 Wiley Online, and these two clips

		https://www.youtube.com/watch?v=ZqfjIeVZLOk and https://www.youtube.com/watch?v=_w7RPikOAk0 Los Angeles is another city known for urban decline and associated problems http://www.bbc.co.uk/education/clips/zxws34j and Curriculum Press Factsheet 314. The impact of regeneration in US cities. Investigate to what extent Britain's high streets (all 5400 of them!) are 'dead', by using: • https://www.youtube.com/watch?v=vc8SFmSvAUs and https://www.youtube.com/watch?v=PR60QL8sOu8 to understand how the increase of fast food/chain stores are affecting Britain's high street. • https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6292/2081646.pdf *The Portas Review* (2011). • Curriculum Press *Geography Factsheet 321. Death of the High Street?* follows up on the ideas in the YouTube clips and the government report. • Investigate whether your high street is a 'clone town'. http://www.rgs.org/OurWork/Schools/Fieldwork+and+local+learning/Local+learning/Fieldwork+in+the+local+area/Clone+town+survey.htm

		Investigate new spaces of consumption including: • http://www.bbc.co.uk/education/clips/zv7vr82 Business parks in Scotland. • http://www.bbc.co.uk/education/clips/zpjs34j Edge Cities in Los Angeles. Use a range of maps such as Figure 2.1 to describe the geographical distribution of the various knowledge economy clusters (education, research, culture/creative industries, digital/IT companies, science and biotechnology) in the UK. Then explain locational factors which encourage cluster growth (proximity to universities and research institutes, government support, planning regulations and infrastructure). Hawkins, H. & Harvey, D. (2010) 'The geographies of the creative industries: scale, clusters and connectivity', *Geography*, 95 (1) pp.14–21. Understand the development and locational factors encouraging the growth of a particular knowledge economy cluster on people and place, such as Cambridge Science Park. Develop an understanding of how it is benefiting the economy (national/local), environment (built/natural) and people (academics, scientists as well as other local groups). Develop this case study in the form of a written report. Learners

		could choose different clusters to investigate, then share their reports. • http://www.ukspa.org.uk/members/csp • http://www.cambridgesciencepark.co.uk • http://www.independent.co.uk/news/business/analysis-and-features/why-cambridge-is-at-the-heart-of-britains-economic-recovery-9134717.html • http://www.bbc.co.uk/education/clips/zs2vr82 Investigate the extent to which Glasgow's Future Cities project, funded by the UK government innovation fund, will improve the life of its residents. http://futurecity.glasgow.gov.uk Startups have attracted investment of more than £1.47 billion to London since 2010. Read the following articles and suggest to what extent their home at Tech City (is as the resources suggest) dying. http://www.balloupr.com/blog/is-london-s-tech-city-dying/ and http://life.spectator.co.uk/2015/09/the-failure-of-londons-tech-city/ Read about the Silicon roundabout redevelopment, how do these projects impact on the local community? http://www.standard.co.uk/news/london/old-street-roundabout-redevelopment-given-go-ahead-after-public-back-25m-transformation-10311172.html

		How is the digital tech economy diversifying and improving Britain's local economies? http://www.ft.com/cms/s/0/2ff60718-d00d-11e5-92a1-c5e23ef99c77.html#axzz40zrR4pkr
2.1.6 The rebranding process and players in rural places.	Learners need to understand how diversification in the post-productive countryside is achieved through re-imaging and regenerating rural places, and through recreation, heritage, media and event management, driven by a number of stakeholders including local groups and external agencies such as the tourist board and conservation organisations. Learners should be aware of the perception of the 'chocolate box' village and the image of the idyllic way of life in the countryside as portrayed by the media and the reality, which can be quite different. Learners also need to be aware of the changing social profile of people who live and work in rural areas, such as wealthy second home owners, retirees, the rural poor and the recent new agricultural immigrants. They need to understand the consequences of rebranding on the perceptions, actions and behaviours of these different groups of people, including those in other places who choose to relocate there.	Terry Marsden and Paul Cloke introduced the concept of the 'post-productive' countryside. 70 per cent of UK land is used for agriculture, but only 1% of workers are in the agricultural sector. Investigate the following: Why rural rebranding is needed in the post-productive countryside, the players involved, the focus of rural rebranding projects through recreation, heritage, media and event management, and whether success can be achieved, by using: • The Eden Project https://www.edenproject.com • Gloucester Services and farm shop http://www.gloucesterservices.com • Dove, J. (2015) 'Adventure tourism in the Lake District: a rebranding case study'. September, 29 (1) *Geography Review*. Hodder Education. • Farmer Ted's Farm Park http://www.farmerteds.com/wp/ • Glastonbury Festival http://www.glastonburyfestivals.co.uk http://www.theguardian.com/environment/2016/jan/14/glastonbury-festival-2014-human-waste-pollution-river-whitelake

		• http://www.originalshrewsbury.co.uk/visit/shrewsbury/history Shrewsbury the town branded as the original one-off. Outline the aims and process of rural rebranding in Priorat based on gastronomic tourism http://geographyfieldwork.com/RuralRebranding.htm and Whitley Bay Curriculum Press *Geography Factsheet 304*. The redevelopment and rebranding of a north eastern seaside resort – Whitley Bay. Develop definitions for the key concepts of urban renewal, redevelopment, regeneration, rebranding, re-imaging, remaking, sustainability, adaptation and thresholds.
2.1.7 Rural management and the challenges of continuity and change.	Learners need to understand how to manage rural change and inequality in diverse communities with reference to examples. Rural issues that need addressing include housing, transport and service provision, including digital connectivity. Learners should be aware that these issues are complex and are a result of structural changes in agriculture, as a result of political decisions, economic change and the evolution of a post-productive countryside. Learners should be able to evaluate both ongoing and new challenges in rural places. Ongoing challenges in rural places are those where regeneration/rebranding are absent or have failed or	Learners will understand ongoing and new issues (out-migration, ageing population, housing availability, physical remoteness and inaccessibility, transport and service provision including digital connectivity) associated with managing rural change and inequality in diverse communities by using: • http://www.telegraph.co.uk/finance/newsbysector/retailandconsumer/12089489/Some-milk-and-how-much-for-the-whole-store-Villagers-square-up-to-rural-shop-decline.html Article on loss of services in rural areas.

	have created conflict. New challenges of managing change in some rural communities are associated with increased levels of counter-urbanisation and second home ownership, and the possible actions that can mitigate the extent of these issues.	• http://www.rsnonline.org.uk/services/rural-bus-services-being-wiped-out Decline in rural bus services. • http://www.theguardian.com/uk-news/2014/jul/09/lake-district-homeowners-local-residents Article about residents being pushed out by holiday homeowners. • Curriculum Press *Geography Factsheet 315*. South Shropshire: A case of Rural Rebranding (The impact of in-migration of retired people to Shropshire). Learners need to understand that rural areas close to large settlements tend to have different issues compared to more remote rural areas, see Cloke's 1979 model of urban-rural continuum. https://www.geography-fieldwork.org/rural/rurality.aspx The digital divide in the UK benefits some rural areas but not others. Investigate some of the winners and losers. Use the following websites: • http://www.rgs.org/OurWork/Schools/Teaching+resources/Key+Stage+5+resources/21st+Century+Challenges/Digital+divide+in+the+UK.htm An introduction to the digital divide. • https://www.rgs.org/NR/rdonlyres/C25A5C2C-0246-49F9-ACD7-

		A542C30BE715/0/DigitalDLesson1ArticleTacklingthedigitaldivide.pdf Tackling the digital divide. • http://www.dotrural.ac.uk/wp-content/uploads/2015/08/TwoSpeedBritain_18Aug2015Final.pdf Two-Speed Britain report from the University of Aberdeen. Learners to create a concept map of ongoing issues and new issues facing both urban and rural areas.

2.1.8 The rebranding process and players in urban places.	Learners need to know and understand how urban places can be re-imaged and regenerated through investment in sport/music stadia, cultural quarters, festivals, industrial heritage and flagship developments. There are many suitable local places that can be used as examples here, such as Cardiff Bay. Be careful with the scale of examples, a city is too big to study. Learners need to appreciate how re-imaging and regenerating urban places takes place in collaboration with external agencies including governments, corporate bodies and community groups, each of which may have their own agenda. Linked to the above, learners must also understand that the way in which the urban place has been re-imaged and regenerated impacts on the actions and	Learners to learn how the re-imaging and regenerating of urban places has taken place through sport/music stadia, cultural quarters, festivals, industrial heritage and flagship developments, using examples such as Bristol Docks, Salford Quays and London Docklands/2012 Olympics and Liverpool. • http://www.s-cool.co.uk/a-level/geography/urban-profiles/revise-it/developed-country-bristols-urban-re-generation Bristol. • http://www.salford.gov.uk/d/milestones_v2.pdf Salford Quays. • http://www.lddc-history.org.uk The London Docklands Development Corporation 1981–1998 and Campkin, B. (2015) *Remaking London: Decline and Regeneration in Urban Culture*. I.B. Tauris: London.

	behaviours of individuals, groups, businesses and institutions.	• Rebranding Liverpool (Brand artefact, strategy and essence) Curriculum Press Factsheet 273. Learners can use actor-network theory to understand the role of stakeholders/players (external agencies including governments, corporate bodies and community groups) involved in the re-imaging and regenerating of urban places, by using: • http://www.sagepub.com/sites/default/files/upm-binaries/5222_Ritzer__Entries_beginning_with_A__[1].pdf • A critical look – London Docklands Revisited. http://oisd.brookes.ac.uk/breakfast_seminars/resources/DocklandsRevisited.pdf
2.1.9 Urban management and the challenges of continuity and change.	Learners need to understand that the processes of re-imaging and regenerating can affect the social and economic characteristics of urban places and may create conflicting perceptions. Conflicting perceptions may develop in different groups of people who live in the urban area, who visit and work there, and who invest in property and businesses.	Discuss the major challenges (such as deindustrialization, depopulation, high unemployment, political disenfranchisement, crime and dereliction) faced in places where regeneration/rebranding are absent or have failed. This is more common in smaller towns such as Hartlepool and Wolverhampton. • http://www.economist.com/news/britain/21587799-these-days-worst-urban-decay-found-not-big-cities-small-ones-urban-ghosts Urban decay.

	Learners should be able to evaluate ongoing challenges in urban places where regeneration/rebranding are absent or have failed or are causing overheating.	• http://www.theguardian.com/cities/2015/jan/20/justin-welby-britain-urban-crisis-cities-abandoned-hopeless Urban crisis. • http://www.theguardian.com/cities/2015/jan/19/north-south-divide-widen-thinktank-data UK's north-south divide. Learners need to understand that there can be issues when regeneration/rebranding causes overheating, by using: • http://www.theguardian.com/cities/2015/dec/23/norman-fosters-cairo-redevelopment-has-locals-asking-where-do-we-fit-in Redevelopment in Cairo for investors not local people. • http://blogs.spectator.co.uk/2015/10/north-london-will-be-boosted-by-hs2-but-the-north-wont-be/ HS2 for North London not for the North. • http://www.standard.co.uk/news/london/antigentrification-protesters-target-cereal-killer-cafe-and-estate-agent-in-shoreditch-a2956481.html Protests against cereal cafes and Estate Agents in Shoreditch. • http://www.theguardian.com/uk-news/2015/aug/16/vince-power-fand-the-last-stand-of-the-notting-hill-bohemians The last pub in Notting Hill.

		Learners should revise subject content, in preparation for planning and writing an essay (essay planners are helpful). http://www.geographypods.com/uploads/7/6/2/2/76228863/essay_planning_tool.pdf
	Learners should understand that the Covid-19 pandemic and further economic change since the Specification was first introduced in 2016 have brought new challenges to some urban areas.	COVID-19 brought significant economic changes to urban areas in the UK, impacting various sectors and aspects of city life. The UK Centre for Cities has a wealth of useful resources for teachers and learners https://www.centreforcities.org/future-of-cities/ The most significant challenges include: • High Street and Retail: Major city centres like London, Manchester, Cardiff, and Bristol experienced sharp declines in retail and hospitality during and following the pandemic due to lockdowns and reduced footfall. Many businesses faced closure, and recovery has been slow, especially in areas heavily reliant on office workers and tourists. • Employment: The pandemic led to job losses and shifts in employment patterns. Sectors such as hospitality, retail, and entertainment were hit hardest, while working from home

		became more prevalent. This shift affected urban economies and the built environment (e.g. office spaces), with some areas struggling more than others to bounce back. • Urban Poor: COVID-19 exacerbated existing socio-economic inequalities, with the urban poor bearing the brunt of the crisis. Increased poverty levels and economic hardship were notable, particularly in densely populated areas. • Environmental Impact: Reduced economic activity and vehicle traffic during lockdowns led to improved air quality in cities. This has sparked discussions about sustainable urban planning and the potential for a greener economic recovery • City Planning and Mobility: The pandemic prompted cities to rethink urban mobility and infrastructure. Measures to encourage cycling and walking were implemented in cities like London and Manchester, aiming to create more resilient and sustainable urban environments.

Books:

Cresswell, T. (2014) *Place: An Introduction, 2nd Edition*. Wiley-Blackwell. http://eu.wiley.com/WileyCDA/WileyTitle/productCd-0470655623.html

Hill, M. (2003) *Rural Settlement and The Urban Impact on the Countryside.* Hodder and Stoughton.

Hill, M. (2005) *Urban Settlement and Land Use.* Hodder Murray: London.

Holloway, L. & Hubbard, P. (2001) *People and Place: The Extraordinary Geographies of Everyday Life.* Harlow: Prentice Hall. http://www.amazon.co.uk/People-Place-Extraordinary-Geographies-Everyday/dp/0582382122

Hubbard, P. & Kitchin, R. (2011) *Key Thinkers on Space and Place*. 2nd Edition, London: Sage Publishing.

Massey, D. (2005) *For Space.* London: Sage Publishing. https://selforganizedseminar.files.wordpress.com/2011/07/massey-for_space.pdf

Oakes, S., Owens, A & Rawlings Smith, E. (2016) *Changing Places.* Geographical Association: Sheffield.

Witherick, M. & Adams, K. (2006) *Cities and Urbanisation* Philip Allan Updates: Oxfordshire.

Additional Resources:

Check current issues for relevant articles in *Geography Review* (Hodder Education), *Geofile* (Oxford University Press) and *Geography Factsheets* (Curriculum Press).

Teaching the new Human Geography from 2016 Conference lecture by Dr Simon Oakes, Eduqas in four separate sections.
https://www.youtube.com/watch?v=-W20IX5L2xs

Valuing Places – Geographical Imaginations. Geographical Association resources.
http://www.geography.org.uk/projects/valuingplaces/cpdunits/geographicalimaginations

Changing Places – New A level Subject Content Overview from the Royal Geographical Society. https://www.rgs.org/NR/rdonlyres/8D8D8306-0825-4FED-B183-40D384DC6DE8/0/SCO_ChangingPlace_ChangingPlaces.pdf

Fieldwork Opportunities

The list in Appendix B of the specification provides suggestions of fieldwork opportunities that may be carried out in relation to each theme. These suggestions are designed as guidance in order to provide starting points and are neither comprehensive nor mandatory.

Additional resources to help place and deliver fieldwork are listed below:

- Changing Landscapes – Coastal Landscapes http://www.geography-fieldwork.org/coast.aspx

- Changing Landscapes – Glaciated Landscapes http://www.geography-fieldwork.org/ice.aspx

- Changing Places
  Counter urbanisation
  Deprivation 1 (Investigation 4)
  Deprivation 2 (Investigation 6)
  Urban inequality and rebranding http://www.geography-fieldwork.org/urban.aspx
  Rural change
  https://docs.google.com/document/d/1Mgg9hUgjURRX7OSsbBVlclD8cIeUngjx-aNyYrC_BPM/edit?usp=sharing
  Rural change 2 http://www.geography-fieldwork.org/rural.aspx

Integrating Skills – Practical Approaches

Geographical skills in relation to both an equal weighting of quantitative and qualitative skills are required for AS and A level learners, and the list in Appendix A of the specification indicates those selected for study for all components in this specification. All the skills need to be addressed within these components but not all will apply to fieldwork. The four required days of fieldwork should contribute to learners building a holistic and balanced understanding of quantitative and qualitative skills related to fieldwork and the six-stage enquiry process.

Definitions:

- Quantitative research is "explaining phenomena by collecting numerical data that are analysed using mathematically based methods (in particular statistics)."
- Qualitative research seeks to answer questions about why and how people behave in the way that they do. It provides in-depth information about human behaviour.

Source: http://www.skillsyouneed.com/learn/quantitative-and-qualitative.html

Additional guidance:

Qualitative skills

- RGS article
- Learning to analyse qualitative data – online tutorial

Quantitative skills

- I-Use project. Including 'How to' video guides and student tasks
- GA 'How to guides' Conducting statistical tests in fieldwork

Learners need to develop competence in using the geographical skills specified in the Geography GCE AS and A level Subject Content (December 2014), as shown in the 'Integrating geographical skills in delivery of the core themes' tables in Appendix A of the specification.

Below are some examples of tasks that can be used to integrate skills into lesson delivery.

Class exercises matched to Geographical Skills

Coastal Landscapes

1.1.1

- use of numerical data to calculate sediment budgets

Constructing accurate sediment budgets is a time consuming process which involves measurement and monitoring of the rates all the major sediment transport processes and storage zones. Complete sediment budgets are therefore relatively unusual; however this example of a sediment budget approach to coastal erosion in South Carolina usefully exemplifies the application of the approach in a coastal management context: http://pubs.usgs.gov/of/2008/1206/html/processes1.html

1.1.2

- measures of central tendency (mean, mode) – mean wave frequency

To estimate wave frequency, count the number of waves over a 10 minute period and divide the total by the number of minutes to determine the mean number of waves per minute.

1.1.3

- scale

Trace a 30–40 km coastline at a range of scales (1: 1000 000, 1: 50 000 and 1:25 000), and comment on the influence of scale on the plan of the coastline.

- landscape system identification

Classification of coastal landscapes according to landscape character type (LCT)

Holmes, D. (2013) Assessing landscapes. *Geography Review* 27 (2) pp.34–36

- digital and geo-located data

Comparisons of characteristics of rocky, sandy and estuarine coastal environments using GIS mapping of the variety of coastal (rocky, sandy and estuarine) landscapes both for and beyond the UK https://www.arcgis.com/home/

NASA's Visible Earth Programme is a source of satellite photographs of coasts http://visibleearth.nasa.gov/

1.1.4

- distance and area

Calculate the maximum fetch using an atlas. Work out the maximum fetch for the following locations:

Aberdeen in north-east Scotland has a fetch of _____ km

Rhossili in south-west Wales has a fetch of _____ km

Dover in south-east England has a fetch of _____ km

Use the formula H = 0.36√F to calculate the maximum possible wave height at these locations, as determined by fetch.

- rose/star/radial diagrams

Draw a wind rose of the tabulated data to show the prevailing wind direction shown below:

Mean percentage frequency of winds in the British Isles											
N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
7	5	6	7	5	8	9	9	14	15	8	7

1.1.5

- field sketches of cliff profiles

A key field skill for geomorphologists is observation. The ability to observe landforms in the field, to systematically record those observations and then apply classroom knowledge of the environment and process to explain the genesis of the forms observed is central. Producing annotated field sketches is a great way to formalise this process. Annotating photographs in the field using appropriate apps such as Skitch, which helps with the labelling and annotation of photographs, is another option (see Holmes, 2013).

Holmes, D. (2013) Fieldwork of the future. *Geography Review* 26 (4) pp.25–27

1.1.6

- sampling

Sampling of beach pebbles, including the ability to identify sources of error in data, measurement errors and misuse of data

http://geographyfieldwork.com/MinimumSampleSize.htm

Article covering coastal fieldwork on a beach

www.thegeographeronline.net/uploads/2/6/6/2/26629356/gf551.pdf

See Holmes, D. (2013) Are your data reliable, accurate and valid? *Geography Review* 26 (3) pp.34–36

- data sets

Samples of beach pebbles, see Holmes, D. (2010) Beach profiles. *Geography Review* 23 (3) pp.5–7

- frequencies

Recorded frequencies of shape of beach pebbles using Power's scale shown in the table below:

Power's scale	Frequency Sample of 20 beach pebbles taken from western location on Pwll Du beach	Power's scale	Frequency Sample of 20 beach pebbles taken from central location on Pwll Du beach	Power's scale	Frequency Sample of 20 beach pebbles taken from eastern location on Pwll Du beach
0	0	0	0	0	0
1	0	1	0	1	0
2	8	2	4	2	0
3	11	3	6	3	0
4	1	4	8	4	7
5	0	5	2	5	9
6	0	6	0	6	4

- measures of central tendency (mode)

Identify the modal Power's scale for each of the 3 samples tabulated above

- measures of dispersion (range, standard deviation, interquartile range)

  http://geographyfieldwork.com/MinimumSampleSize.htm

Smaller standard deviations reflect more clustered data. More clustered data means less extreme values. A data set with less extreme values has a more reliable mean. The standard deviation is therefore a good measure of the reliability of the mean value. The formula is as follows:

$$\sigma = \sqrt{\frac{\sum (x - \bar{x})^2}{n}}$$

σ = standard deviation

$\sum$ = sum of

x = each value in the data set

$\bar{x}$ = mean of all values in the data set

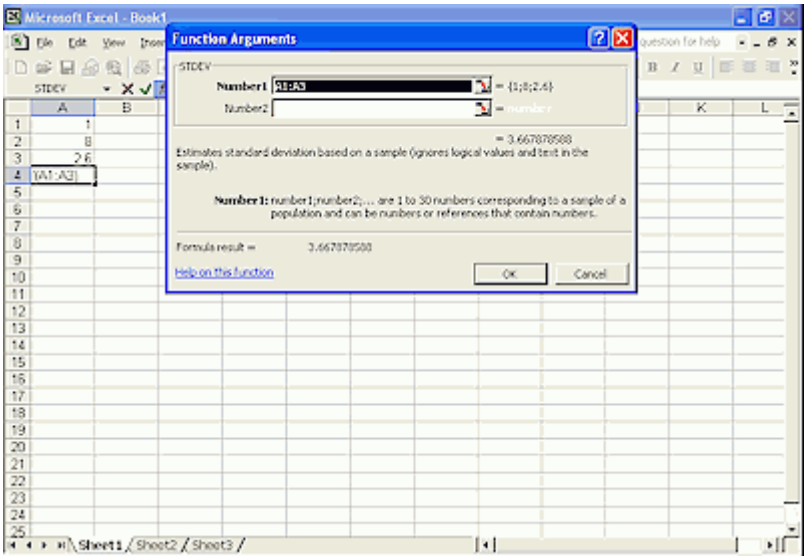
n = number of value in the data set

Is there an easy way to calculate it?

The Microsoft Excel programme will automatically calculate the standard deviation and mean for a set of data listed in a spreadsheet column.

Method:

- List data set in a single column
- Click on the empty cell below the last data item
- Open INSERT menu > FUNCTION > STDEV > click OK
- The standard deviation is then shown and will appear in the empty cell.
- The excel screen example below is for a data set of 3 items



Pebble data set of 30 pebble long axes from Site 1 Stiges beach, Spain. Calculate the range, standard deviation and interquartile range of the sample.

Pebble number	Long Axis (cm)
1	10
2	9
3	8
4	8
5	16
6	12
7	8.5
8	10
9	12
10	9
11	13
12	14
13	10
14	14
15	17
16	12
17	6

18	17
19	9
20	5
21	10
22	7.5
23	13
24	13
25	7.5
26	15
27	12
28	8
29	22
30	16

Mean	11.20 cm
Standard Deviation	3.81 cm
Range	5 cm – 22 cm = 17 cm
Interquartile range	8.5 cm – 14 cm = 5.5 cm

Samples of beach pebbles were taken at 12 locations spread west to east along Pwll Du beach, Gower, at intervals of 25 m as shown in the table below:

Sampling point	1 (W)	2	3	4	5	6	7	8	9	10	11	12 (E)
Distance (m)	0	25	50	75	100	125	150	175	200	225	250	275
Particles < 10 mm *x*-axis (%)	3	4	12	16	9	26	42	34	60	73	71	78

i) Draw a scatter plot to show the relationship between distance (west to east) along Pwll Du beach and the % particles with *x*-axis < 10 mm size of particles

ii) Draw a line of best fit

iii) Analyse the statistical significance of the relationship using Spearman Rank Correlation Coefficient

- Spearman's Rank Correlation Coefficient

This is a technique which can be used to summarise the strength and direction (negative or positive) of a relationship between two variables. The result will always be between 1 and minus 1.

Method – calculating the coefficient:

- Create a table from your data.
- Rank the two data sets. Ranking is achieved by giving the ranking '1' to the biggest value in a column, '2' to the second biggest value and so on. The smallest value in the column will get the lowest ranking. This should be done for both sets of measurements.
- Tied scores are given the mean (average) rank.
- Find the difference in the ranks (d): This is the difference between the ranks of the two values on each row of the table. The rank of the second value (% particles with x-axis < 10 mm) is subtracted from the rank of the first (sampling point).
- Square the differences (d^2) to remove negative values and then sum them ($\sum d^2$).

Distance (m)	Rank	% particles with x-axis < 10 mm	Rank	Difference (d)	Difference squared (d^2)
0	12	3	12	0	0
25	11	4	11	0	0
50	10	12	9	–1	1
75	9	16	8	–1	1
100	8	9	10	2	4
125	7	26	7	0	0
150	6	42	5	–1	1
175	5	34	6	1	1
200	4	60	4	0	0
225	3	73	2	–1	1
250	2	71	3	1	1
275	1	78	1	0	0
$\sum d^2$ = 10					

- Calculate the coefficient (R) using the formula below. The answer will always be between 1.0 (a perfect positive correlation) and –1.0 (a perfect negative correlation).

When written in mathematical notation, the Spearman Rank formula looks like this:

$$(R) = 1 - \frac{6\sum d^2}{n^3 - n}$$

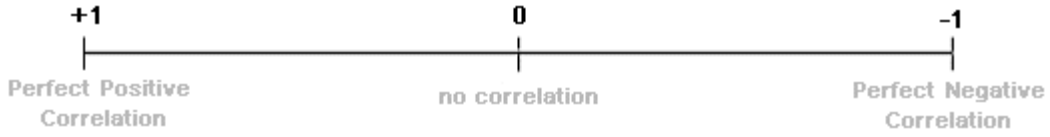
Now put all these values into the formula.

- Find the value of all the d^2 values by adding up all the values in the Difference squared (d^2) column. In our example, this is 10. Multiplying this by 6 gives 60.
- Now for the bottom line of the equation. The value n is the number of sites at which you took measurements. In our example, this is 12. Substituting these values into $n^3 - n$ we get 1728 – 12
- We now have the formula: $R = 1 - (60/1716)$ which gives a value for R:

$$1 - 0.03 = 0.97$$

What does this *R* value of 0.97 mean?

The closer R is to +1 or –1, the stronger the likely correlation. A perfect positive correlation is +1 and a perfect negative correlation is –1. The R value of 0.97 suggests a very strong positive relationship.



A further technique is now required to test the significance of the relationship.

The R value of 0.97 must be looked up on the Spearman Rank significance table below as follows:

- Work out the 'degrees of freedom' you need to use. This is the number of pairs in your sample minus 2 ($n - 2$). In the example, it is 10 (12 – 2).
- Now plot your result on the table.
- If it is below the line marked 5%, then it is possible your result was the product of chance and you must reject the hypothesis.
- If it is above the 0.1% significance level, then we can be 99.9% confident the correlation has not occurred by chance.
- If it is above 1%, but below 0.1%, you can say you are 99% confident.
- If it is above 5%, but below 1%, you can say you are 95% confident (i.e. statistically there is a 5% likelihood the result occurred by chance).

In the example, the value 0.97 gives a significance level of more than 0.1%. That means that you can be 99.9% certain that your hypothesis is correct.

The significance of the Spearman's Rank Correlation Coefficients and degrees of freedom.

- The fact that two variables correlate cannot prove anything – only further research can actually prove that one thing affects the other.
- Data reliability is related to the size of the sample. The more data you collect, the more reliable your result.

Click Spearman's Rank Significance Graph for a blank copy of the significance graph.

- inferential statistics, including Chi-square

The Chi-squared test (X^2) is used to test whether there is a significant difference between data. It can only be used on data which has the following characteristics:

i) The data must be in the form of frequencies counted in a number of groups (% cannot be used).
ii) The total number of observations must be > 20.
iii) The observations must be independent (i.e. one observation must not influence another).
iv) The expected frequency in any one category must not normally be > 5.

Method – calculating X^2:

- State the hypothesis being tested – there is a significant difference between sample groups. It is convention to give a null hypothesis – no significant difference between the samples.
- Tabulate the data as shown in the example below. The data being tested for significance is the 'observed' frequency and the column headed 'O'.
- Calculate the 'expected' number of frequencies that you would expect to find in the column headed 'E'.
- Calculate the statistic using the formula $X^2 = \sum (\text{Observed} - \text{Expected})^2 \div \text{Expected}$
- Calculate the degrees of freedom.
- Compare the calculated figure with the critical values in the significance tables using the appropriate degrees of freedom. Read off the probability that the data frequencies you are testing could have occurred by chance.

Example (using one sample):

In an investigation into the size of material deposited on a beach it was noticed there were differences with increasing distance along the beach, with pebbles appearing to become smaller. X^2 can be used to test if the variations in pebble size are significant or random. The data in the table below shows the number of pebbles over 5 cm long in a quadrat at 4 sites along a beach between 2 groynes.

Beach site	Observed number of pebbles > 5 cm long
1	40
2	15
3	5
4	12

1. The null hypothesis (H_0) states that there is **no significant difference** in the sizes of pebbles sampled along the beach. The alternative hypothesis (H_1) is that there is a **significant difference** in the sizes of pebbles sampled along the beach.
2. If there is no difference in the sizes of pebbles, the sites should all have approximately the same frequency of pebbles > 5 cm.
3. Place the data into a table (see below).

	O	E	(O–E)	$(O–E)^2$	$(O–E)^2/E$
Beach site	Number of pebbles > 5 cm long	Mean number of pebbles > 5 cm long			
1	40	18	22	484	20.89
2	15	18	3	9	0.5
3	5	18	13	169	9.39
4	12	18	6	36	2
					Σ 38.78

4. Calculate the degrees of freedom (df) = number of rows – 1 = (4 – 1) = 3
5. The critical values for 3 df are:
   0.05 (95% confidence level) = 7.82
   0.01 (99% confidence level) = 11.34
6. As the calculated value of **38.78** exceeds the tabulated figure at 3 degrees of freedom at the 99% confidence (11.34), it can be stated with 99% confidence that there is a statistically significant difference in pebble size along this stretch of beach.
7. The next stage is to explain the result.

Example (using <u>two</u> samples):

The following figures provide data on the distribution of pebbles of different shapes on the foreshore (intertidal) and storm ridge (top of beach) zones of Pwll Du beach. Pwll Du is a shingle beach on the south-eastern coast of the Gower peninsular.

Sediment shape influences sediment movement. By using the dimensions of the 3 axes, larger beach particles can be placed in one of the 4 shape categories:

Disc – flat and round

Sphere – like a ball

Rod – long and thin

Blade – long and flat

The 3 dimensional shape of a particle influences its movement. Rod and sphere shaped particles roll more easily. Blades can roll, but not as well as rods and spheres, and they are not thrown as effectively as discs.

Pebble shape					ROW TOTAL
	Observed foreshore	Expected foreshore	Observed storm ridge	Expected storm ridge	
Discs	6	23	40		46
Blades	12		31		43
Rods	29		17		46
Spheres	53		12		65
Column Total	100		100		200

For each cell, calculate the Expected value (E) by multiplying the row total by the column total and dividing your result by the overall total. For example, multiply the row total for discs (46) by the column total of pebbles sampled from the foreshore (100), and divide this figure by the total number of 200 pebbles. This gives an expected value of 23.

Pebble shape					ROW TOTAL
	Observed foreshore	Expected foreshore	Observed storm ridge	Expected storm ridge	
Discs	6	23	40	23	46
Blades	12	21.5	31	21.5	43
Rods	29	23	17	23	46
Spheres	53	32.5	12	32.5	65
Column Total	100		100		200

$X^2 = \Sigma\,(\text{Observed} - \text{Expected})^2 \div \text{Expected}$

$X^2 = (6 - 23)^2 \div 23 + (12 - 21.5)^2 \div 21.5 + (29 - 23)^2 \div 23 + (53 - 32.5)^2 \div 32.5 +$

$(40 - 23)^2 \div 23 + (31 - 21.5)^2 \div 21.5 + (17 - 23)^2 \div 23 + (12 - 32.5)^2 \div 32.5$

$X^2 = 12.56 + 4.20 + 1.56 + 12.93 + 12.56 + 4.20 + 1.56 + 12.93$

$X^2 = 62.5$

Degrees of Freedom = number of rows –1 × columns –1 = 3 × 1 = 3

The tabulated figure at 3 degrees of freedom at the 99% confidence level is 11.34. As the calculated value of 62.5 is above this, it can be stated with 99% confidence that there is a statistically significant difference between the distribution of observed pebble shapes between foreshore and storm ridge.

Table: Chi-Square Probabilities

The areas given across the top are the areas to the right of the critical value. To look up an area on the left, subtract it from one, and then look it up (i.e. 0.05 on the left is 0.95 on the right).

df	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005
1	---	---	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.070	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757

Suggest reasons for the result of the Chi-square test:

- cross-sections and long profiles

Beach transects

Holmes, D. (2010) Beach profiles. *Geography Review* 23 (3) pp.5–7

1.1.7

- cross-sections and long profiles

Cross-section of sand dune *Geography Review* January 2003

Holmes, D. (2003) Investigating coastal sand dunes. *Geography Review* 16 (3) pp.16–20

1.1.8

Ordnance Survey maps (1:25 000) map interpretation of a distinctive landform indicating past sea level change

1.2.1

- glacier mass balance

Year	Winter (metres of water equivalent)	Summer (metres of water equivalent)	Net glacier budget (metres of water equivalent)
1985	2.18	–3.38	–1.20
1986	2.45	–3.06	–0.61
1987	2.04	–4.10	
1988	2.44	–3.78	
1989	2.43	–3.34	
1990	2.60	–2.71	
1991	3.54	–3.47	
1992	1.91	–3.92	
1993	1.98	–3.21	
1994	2.39	–3.99	
1995	2.86	–3.55	
1996	2.94	–2.84	
1997	3.71	–3.08	
1998	2.76	–4.62	
1999	3.59	–2.57	
2000	3.32	–2.94	
2001	1.90	–3.47	
2002	4.02	–3.47	
2003	2.66	–4.76	
2004	2.08	–3.73	
2005	1.97	–4.42	

i) Complete the table by calculating the figures for the net glacial budget column.
ii) Present the data in the form of a line graph.
iii) Describe the trends shown by the graph.
iv) To what extent does the graph support the evidence of glacial retreat?

Use GIS and aerial photo interpretation to calculate mean rates of glacial retreat
https://nsidc.org/glims/glaciermelt/

Retreat of the Sierra de Sangra Glaciers
http://visibleearth.nasa.gov/view.php?id=87541

Monitoring of changing areal extent of Swiss glaciers
https://vaw.ethz.ch/en/research/glaciology/glacier-monitoring.html

1.2.2

1.2.3

1.2.4

- distance and area
- scale

Comparison of past and present distribution of glaciated landscapes: table summarising their volume and extent.

Ice sheet	Area	Present volume	Devensian maximum
Laurentide ice sheet (North America)	10.2 – 11.3 × 10^6 km^2	0	34.8 × 10^6 km^3
Greenland ice sheet	1.7 × 10^6 km^2	2.4 × 10^6 km^3	3.5 × 10^6 km^3
Antarctica	14 × 10^6 km^2	30 × 10^6 km^3	34 × 10^6 km^3

Types of ice mass at a range of scales

Monitoring of changing area of Swiss glaciers
https://vaw.ethz.ch/en/research/glaciology/glacier-monitoring.html

NASA's Visible Earth Programme is a source of satellite photographs of landscapes shaped by glaciers
http://disc.sci.gsfc.nasa.gov/geomorphology/GEO_9

1.2.5

- cross-section

Geography Advanced Topic Masters: *Glaciation & Periglaciation*. Author: Jane Knight 144pp • 978 1 844 89617 2

OS map cross-section of Nant Ffrancon valley p.36

- Ordnance Survey maps

Cirque orientation analysis using OS maps and rose diagram (see below).

- field sketches of landforms of glacial erosion

  A key field skill for geomorphologists is observation. The ability to observe landforms in the field, to systematically record those observations and then apply classroom knowledge of the environment and process to explain the genesis of the forms observed is central. Producing annotated field sketches is a great way to formalise this process. Annotating photographs in the field using appropriate apps such as Skitch, which helps with the labelling and annotation of photographs, is another option (see Holmes, 2013).

Holmes, D. (2013) Fieldwork of the future. *Geography Review* 26 (4) pp.25–27

1.2.6

- sampling

Sampling of glacial clasts, including the ability to identify sources of error in data, measurement errors and misuse of data

http://geographyfieldwork.com/MinimumSampleSize.htm

- data sets

Samples of glacial clasts, see Swain, L & Kedwards, D. (2007) Analysing glacial deposits. *Geography Review* 20 (5) pp.26–30

- frequencies
- measures of central tendency (mode)

Recorded frequencies of shape of samples of glacial clasts using Power's scale shown in the table below:

Power's scale	Frequency	Power's scale	Frequency	Power's scale	Frequency
0	8	0	39	0	0
1	37	1	35	1	5
2	41	2	16	2	19
3	11	3	5	3	30
4	3	4	3	4	21
5	0	5	2	5	15
6	0	6	0	6	10

Identify the modal Power's scale for each of the 3 samples tabulated above.

- measures of dispersion (range, standard deviation, interquartile range)

Calculate the range, standard deviation and interquartile range from a sample of glacial clasts.

Smaller standard deviations reflect more clustered data. More clustered data means less extreme values. A data set with less extreme values has a more reliable mean. The standard deviation is therefore a good measure of the reliability of the mean value. The formula is as follows:

$$\sigma = \sqrt{\frac{\sum (x - \bar{x})^2}{n}}$$

σ = standard deviation

$\sum$ = sum of

x = each value in the data set

$\bar{x}$ = mean of all values in the data set

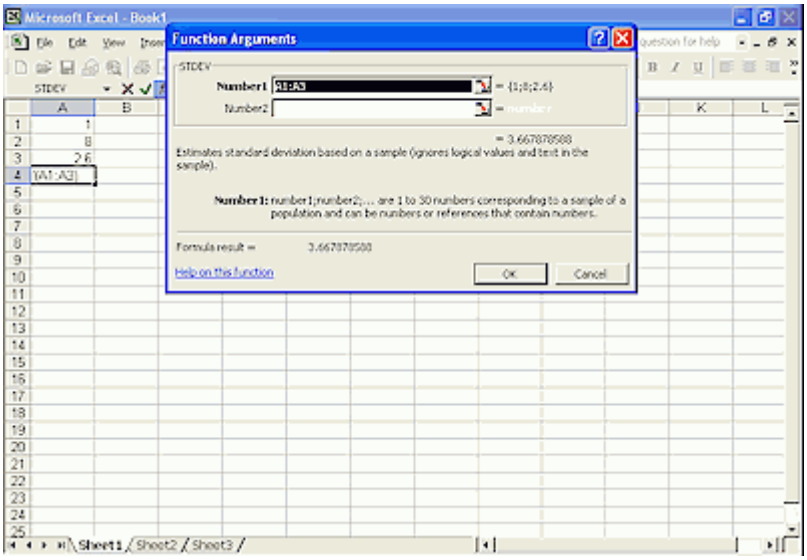
n = number of value in the data set

Is there an easy way to calculate it?

The Microsoft Excel programme will automatically calculate the standard deviation and mean for a set of data listed in a spreadsheet column.

Method:

- List data set in a single column
- Click on the empty cell below the last data item
- Open INSERT menu > FUNCTION > STDEV > click OK
- The standard deviation is then shown and will appear in the empty cell.
- The excel screen example below is for a data set of 3 items


Microsoft Excel - Book1
Function Arguments
STDEV
Number1
Number2
= 3.667878588
Estimates standard deviation based on a sample (ignores logical values and text in the sample).
Number1: number1;number2;... are 1 to 30 numbers corresponding to a sample of a population and can be numbers or references that contain numbers.
Formula result = 3.667878588
Help on this function
OK
Cancel
Sheet1
Sheet2
Sheet3

Data set of 30 long axes measurements from a sample of 30 glacial clasts. Calculate the range, standard deviation and interquartile range of the sample.

Pebble number	Long Axis (cm)
1	10
2	9
3	8
4	8
5	16
6	12
7	8.5
8	10
9	12
10	9
11	13
12	14
13	10
14	14
15	17
16	12
17	6
18	17
19	9
20	5
21	10
22	7.5
23	13
24	13
25	7.5
26	15
27	12
28	8
29	22
30	16

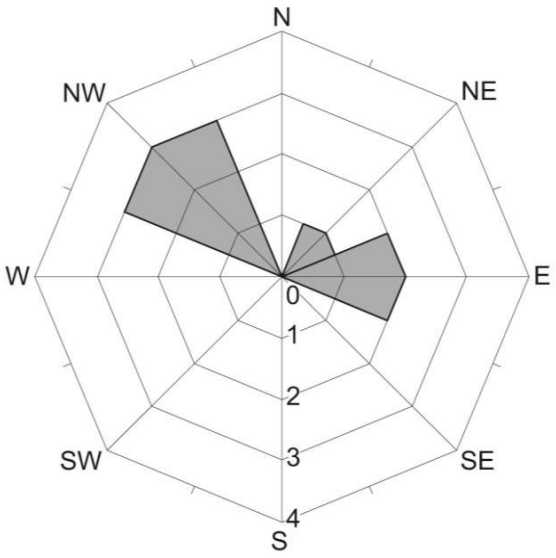
Mean	11.20 cm
Standard Deviation	3.81 cm
Range	5 cm – 22 cm = 17 cm
Interquartile range	8.5 cm – 14 cm = 5.5 cm

Table 11 of named cirques and their orientation

Cirque	Name of cirque	Orientation
A	Craig Maesglas	NE
B	Craig Portas	N
C	Glaslyn	E
D	Llyn Bochlwyd	N
E	Llyn Cau	E
F	Llyn Coch	NW
G	Llyn Du'r Arddu	NW
H	Llyn Gafr	NW
I	Llyn Llydaw	N
J	Llyn y Gadair	N

Use the data in the table above to complete the rose diagram for the orientation of cirques in Wales.

Key: Number of cirques (1 to 4)



1.2.7

- landscape system identification

Classification of glacial landscapes according to landscape character type (LCT)

Holmes, D. (2013) Assessing landscapes. *Geography Review* 27 (2) pp.34–36

1.2.8

Samples of scree deposits were taken at 12 locations along a transect from the top to the base of a scree shown in the table below:

Sampling point along transect	1 (Top of scree)	2	3	4	5	6	7	8	9	10	11	12 (Base of scree)
Distance (m)	0	5	10	15	20	25	30	35	40	45	50	55
Mean length of *x*-axis (cm)	13	14	22	26	19	27	42	34	60	73	71	78

i) Draw a scatter plot to show the relationship between distance (top to bottom of scree) and the mean length of *x*-axis (cm)

ii) Draw a line of best fit

iii) Analyse the statistical significance of the relationship using Spearman's Rank Correlation Coefficient.

The scatter graph shows the possibility of a positive correlation between the two variables and the Spearman's Rank Correlation technique should be used to see if there is indeed a correlation, and to test the strength of the relationship.

- Spearman's Rank Correlation Coefficient

A correlation can easily be drawn as a scatter graph, but the most precise way to compare several **pairs of data** is to use a statistical test – this establishes whether the correlation is really significant or if it could have been the result of chance alone. Spearman's Rank Correlation Coefficient is a technique which can be used to summarise the strength and direction (negative or positive) of a relationship between two variables.

The result will always be between 1 and minus 1.

Method – calculating the coefficient:

- Create a table from your data.
- Rank the two data sets. Ranking is achieved by giving the ranking '1' to the biggest value in a column, '2' to the second biggest value and so on. The smallest value in the column will get the lowest ranking. This should be done for both sets of measurements.
- Tied scores are given the mean (average) rank.
- Find the difference in the ranks (d): This is the difference between the ranks of the two values on each row of the table. The rank of the second value is subtracted from the rank of the first (distance).
- Square the differences (d^2) to remove negative values and then sum them ($\sum d^2$).

Distance (m)	Rank	Length of *x*-axis (cm)	Rank	Difference (d)	Difference squared (d^2)
0	12	13	12	0	0
5	11	14	11	0	0
10	10	22	9	–1	1
15	9	26	8	–1	1
20	8	19	10	2	4
25	7	27	7	0	0
30	6	42	5	–1	1
35	5	34	6	1	1
40	4	60	4	0	0
45	3	73	2	–1	1
50	2	71	3	1	1
55	1	78	1	0	0
$\sum d^2$ = 10					

- Calculate the coefficient (R) using the formula below. The answer will always be between 1.0 (a perfect positive correlation) and –1.0 (a perfect negative correlation).

When written in mathematical notation, the Spearman Rank formula looks like this:

$$(R) = 1 - \frac{6\sum d^2}{n^3 - n}$$

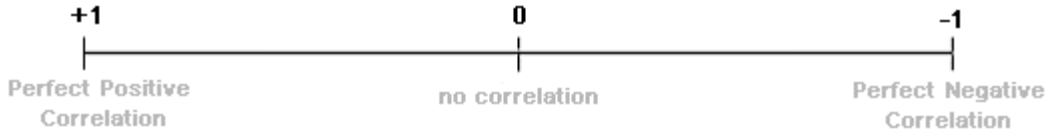
Now put all these values into the formula.

- Find the value of all the d^2 values by adding up all the values in the Difference squared (d^2) column. In our example, this is 10. Multiplying this by 6 gives 60.
- Now for the bottom line of the equation. The value n is the number of sites at which you took measurements. In our example, this is 12. Substituting these values into $n^3 - n$ we get 1728 – 12
- We now have the formula: $R = 1 - (60/1716)$ which gives a value for R:

$$1 - 0.03 = 0.97$$

What does this *R* value of 0.97 mean?

The closer R is to +1 or –1, the stronger the likely correlation. A perfect positive correlation is +1 and a perfect negative correlation is –1. The R value of 0.97 suggests a very strong positive relationship.



A further technique is now required to test the significance of the relationship.

The R value of 0.97 must be looked up on the Spearman Rank significance table below as follows:

- Work out the 'degrees of freedom' you need to use. This is the number of pairs in your sample minus 2 (n – 2). In the example, it is 10 (12 – 2).
- Now plot your result on the table.
- If it is below the line marked 5%, then it is possible your result was the product of chance and you must reject the hypothesis.
- If it is above the 0.1% significance level, then we can be 99.9% confident the correlation has not occurred by chance.
- If it is above 1%, but below 0.1%, you can say you are 99% confident.
- If it is above 5%, but below 1%, you can say you are 95% confident (i.e. statistically there is a 5% likelihood the result occurred by chance).

In the example, the value 0.97 gives a significance level of more than 0.1%. That means that you can be 99.9% certain that your hypothesis is correct.

- The fact that two variables correlate cannot prove anything – only further research can actually prove that one thing affects the other.
- Data reliability is related to the size of the sample. The more data you collect, the more reliable your result.

Click Spearman's Rank Significance Graph for a blank copy of the above significance graph.

- inferential statistics, including Chi-square

The Chi-squared test (X^2) is used to test whether there is a significant difference between data. It can only be used on data which has the following characteristics:

i) The data must be in the form of frequencies counted in a number of groups (% cannot be used).
ii) The total number of observations must be > 20.
iii) The observations must be independent (i.e. one observation must not influence another).
iv) The expected frequency in any one category must not normally be > 5.

Method – calculating X^2:

- State the hypothesis being tested – there is a significant difference between sample groups. It is convention to give a null hypothesis – no significant difference between the samples.
- Tabulate the data as shown in the example below. The data being tested for significance is the 'observed' frequency and the column headed 'O'.
- Calculate the 'expected' number of frequencies that you would expect to find in the column headed 'E'.
- Calculate the statistic using the formula $X^2 = \sum (\text{Observed} - \text{Expected})^2 \div \text{Expected}$
- Calculate the degrees of freedom.
- Compare the calculated figure with the critical values in the significance tables using the appropriate degrees of freedom. Read off the probability that the data frequencies you are testing could have occurred by chance.

Example (using one sample):

The following figures provide data on the number of cirques and their orientation.

Orientation of cirques	Number of cirques
NE	40
SE	15
SW	5
NW	12

1. The null hypothesis (H_o) states that there is **no significant difference** in the orientation of cirques sampled. The alternative hypothesis (H_1) is that there is a **significant difference** in the orientation of cirques.
2. If there is no difference in the orientation of cirques, they should all have approximately the same frequency.
3. Place the data into a table (see below).

	O	E	(O–E)	$(O–E)^2$	$(O–E)^2/E$
Orientation of cirques	Number of cirques	Mean number of cirques			
NE	40	18	22	484	20.89
SE	15	18	3	9	0.5
SW	5	18	13	169	9.39
NW	12	18	6	36	2
∑ 38.78					

4. Calculate the degrees of freedom (df) = number of rows – 1 = (4 – 1) = 3
5. The critical values for 3 df are:
   0.05 (95% confidence level) = 7.82
   0.01 99% confidence level) = 11.34
6. As the calculated value of 38.78 exceeds the tabulated figure at 3 degrees of freedom at the 99% confidence (11.34), it can be stated with 99% confidence that there is a statistically significant difference in the frequency of cirques and their orientation.
7. The next stage is to explain the result.

Example (using two samples):

The following figures provide data on the distribution of scree deposits of different sizes on the upper part and lower part of the scree at Mewslade. Mewslade is a dry valley on the south-western coast of the Gower peninsular.

Scree size (long axis cm)					ROW TOTAL
	Observed 20–24.9 m from free face	Expected lower scree	Observed 0–4.9 m from free face	Expected upper scree	
0–50	6	23	40		46
51–100	12		31		43
101–150	29		17		46
151–200	53		12		65
Column Total	100		100		200

For each cell, calculate the Expected value (E) by multiplying the row total by the column total and dividing your result by the overall total. For example, multiply the row total for scree particles between 0–50 cm 20–24.9 m from the free face (46) by the column total of scree particles 20–24.9 m from the free face (100), and divide this figure by the total number of scree particles (200). This gives an expected value of 23.

Scree size (long axis cm)					ROW TOTAL
	Observed 20–24.9 m from free face	Expected lower scree	Observed 0–4.9 m from free face	Expected upper scree	
0–50	6	23	40	23	46
51–100	12	21.5	31	21.5	43
101–150	29	23	17	23	46
151–200	53	32.5	12	32.5	65
Column Total	100		100		200

$X^2 = \sum (\text{Observed} - \text{Expected})^2 \div \text{Expected}$

$X^2 = (6 - 23)^2 \div 23 + (12 - 21.5)^2 \div 21.5 + (29 - 23)^2 \div 23 + (53 - 32.5)^2 \div 32.5 +$

$(40 - 23)^2 \div 23 + (31 - 21.5)^2 \div 21.5 + (17 - 23)^2 \div 23 + (12 - 32.5)^2 \div 32.5$

$X^2 = 12.56 + 4.20 + 1.56 + 12.93 + 12.56 + 4.20 + 1.56 + 12.93$

$X^2 = 62.5$

Degrees of Freedom = number of rows –1 × columns –1 = 3 × 1 = 3

The tabulated figure at 3 degrees of freedom at the 99% confidence level is 11.34. As the calculated value of 62.5 is above this, it can be stated with 99% confidence that there is a statistically significant difference between the size of scree deposits on the upper part and lower part of the scree.

Table: Chi-Square Probabilities

The areas given across the top are the areas to the right of the critical value. To look up an area on the left, subtract it from one, and then look it up (i.e. 0.05 on the left is 0.95 on the right).

df	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005
1	---	---	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.070	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757

Suggest reasons for the result of the Chi-square test.

Spare tables re: glacial clasts below:

Orientation (°)	Frequency	Orientation (°)	Frequency	Orientation (°)	Frequency
1–30	5	1–30	4	1–30	3
31–60	10	31–60	2	31–60	3
61–90	14	61–90	3	61–90	8
91–120	11	91–120	11	91–120	15
121–150	15	121–150	19	121–150	17
151–180	3	151–180	5	151–180	8
181–210	6	181–210	4	181–210	2
211–240	2	211–240	1	211–240	3
241–270	14	241–270	6	241–270	5
271–300	11	271–300	11	271–300	12
301–330	4	301–330	19	301–330	17
331–360	5	331–360	15	331–360	7

	Till sample 1		Till sample 2	
Clast number	Orientation (°)	Length of A-axis (cm)	Orientation (°)	Length of A- axis (cm)
1	100	4.8	162	3.9
2	70	6.9	17	3.5
3	95	5.0	51	7.6
4	54	20.5	121	7.0
5	70	22.0	126	8.0
6	85	11.5	32	7.2
7	227	6.0	32	7.2

8	225	7.5	14	10.9
9	232	10.5	139	3.6
10	170	4.5	120	11.0
11	80	7.0	156	9.6
12	100	6.0	89	10.0
13	121	15.5	18	4.8
14	120	12.0	58	12.2
15	152	9.8	149	7.0
16	104	6.0	100	7.0
17	166	5.6	100	11.4
18	100	7.0	61	31.0
19	120	6.5	72	4.0
20	120	4.0	140	5.9