Cambridge NATIONALS

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SAMPLE LEARNER WORK WITH COMMENTARY

UNIT R071: HOW SCIENTIFIC IDEAS HAVE AN IMPACT ON OUR LIVES

SCIENCE

Level 1/2

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Oxford Cambridge and RSA

CONTENTS

INTRODUCTION

This is a guide for teachers so that you can see how we would mark work, Cambridge Nationals are designed to give the students the project and let them create the work.

The guide contains sample learner work for this unit and covers all learning objectives, graded at Marking Band 1 (MB1) and Marking Band 3 (MB3).

The accompanying commentary explains why each piece of work was awarded its grade.

For MB1 graded work, additional guidance has been added to suggest improvements that could be made to make it an MB2 graded piece of work.

For MB3 graded work, additional guidance has been added to explain why it was awarded that grade and not the lower grade of MB2.

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Sample Learner Work Marking Band 1

SAMPLE LEARNER WORK

Task 1 - Choosing an energy supply

A public enquiry will be held to collect evidence to help choose one energy supply scheme for a new community on the West coast of England.

Interest group

I represent the local householders of Formby on the West coast of England.

Google maps

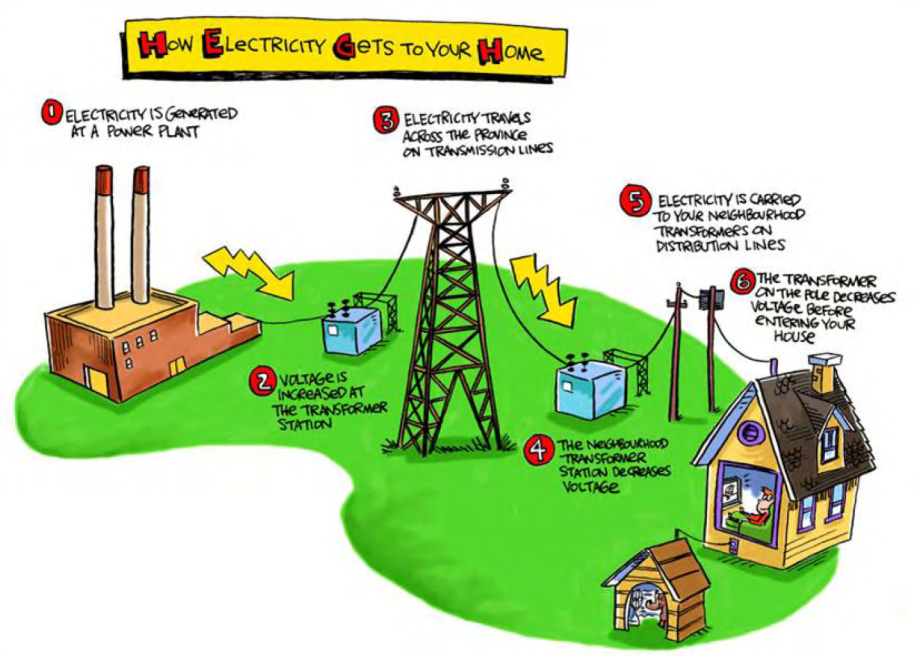
Formby residences are well to do people who have retired to the coast or work in Liverpool and can afford to live outside it. In the summer it has lots of tourists who come for the beaches and seaside.

The different types of energy sources that could be built

Energy source	Advantage	Disadvantage
Wind	Always get wind Free source Cheap to run Does not give off CO2	Tall Stop in high wind Birds can fly into them Noisy
Solar	Free source Always have the Sun Does not give off CO2	Need lots Expensive Not much electricity Does not work at night/winter
Wave	Free source Can be hidden by the sea Always have waves Does not give off CO2	Rough seas breaks them Not developed yet High cost Get in the way of shipping
Tidal	Free source Always have tides Does not give off CO2 Barrage can be used as a road Propellers can be under sea	Need an estuary
Coal oil, gas	Cheap energy	Needs storage Limited reserves Gives out CO2 Gives out fumes Large buildings Need to transport in fuel

SAMPLE LEARNER WORK

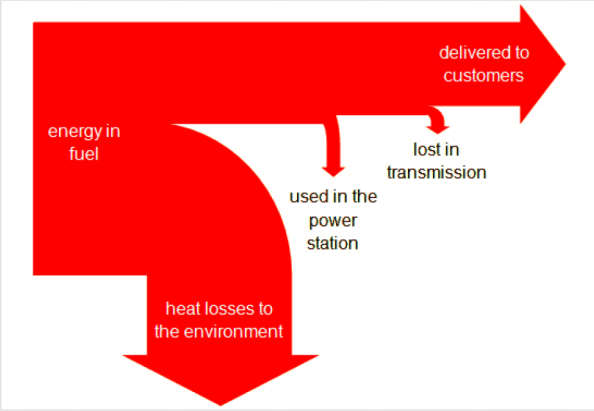
All energy sources will need to connect to the national grid so will need cables and pylons which are unsightly.



From: national grid, education

Efficiency of electricity transfer

Efficiency of transfer
The voltage is stepped up to stop loss of energy from heat in resistance to the cables, then stepped down for safe use. This looses10% of generated electricity.
Efficiency of sources
From my experiments: Wind turbine was more efficient than a Water turbine by a small amount.
From my research: coal power stations are again more efficient than a wind turbine .
Heat given off by burning fuel turns water to steam, this is used as moving energy to turn a turbine which turns a generator to produce electricity energy is lost to the environment at each stage.



From: BBC
But the most efficient source of all is hydroelectric.

SAMPLE LEARNER WORK

Survey of householders concerns

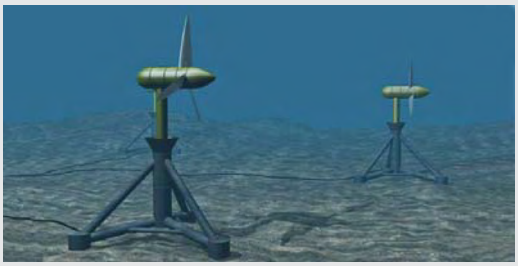
Main concerns of householders:

- House prices come down
- Damage the sight of landscape with building
- More traffic to station
- TV reception
- Noise
- Smell of fumes
- Effect global warming
- Renewable so always have electricity
- Cost
- Ruin coast so no tourism

Vote

Solar farm	18
Wind farm	15
Wind farm at sea	16
Tidal undersea	20
Coal, oil, gas	6
Nuclear	5

The tidal source was the best if it was propellers under the water out of sight.
This would not spoil the landscape.
Sustainable as always a tide.
Cheap when built.
No noise, no smell, no traffic to site.
No CO_2 - no global warming.



All the tides around Britain could give 20% of Britain's needs so tidal source could be used elsewhere, it does not just have to supply near the coast because you can put the electricity anywhere using the National Grid.

SAMPLE LEARNER WORK

Task 2 – Nuclear radiation – the benefits, drawbacks and risks

Explanation why nuclear ionising radiation is used despite the associated risks.

Radiation is energy that can travel through space as a wave or particle.
We are all exposed to background radiation, we even have radiation in food we eat (bananas) and water we drink. We are hit by cosmic rays from Space daily.

Nuclear ionising radiation is used in hospitals:

Images:
X-rays can be used with nuclear ionising radiation from Iodine-123 can produce an image on a CT scan.
An example is the Imaging with radioactive technetium-99m can help diagnose bone infections.
Risk:
Although X-rays do not nuclear ionising radiation they will count to a person's overall exposure to radiation.

Chest X-ray	**0.02 mSv**	equivalent to the amount of radiation you would be exposed to during a return flight from London to Spain
Medical tests for a year	**0.4 mSv**	average dose for each person in the UK
Natural radiation	**2.2 mSv**	annual dose that a person in the UK receives from natural sources

Nuclear tracers:
Gamma rays are used to help diagnosis; a mild radioactive substance is injected into the blood stream so it shows up better on an imaging scan. The benefits of nuclear tracers are that a doctor does not have to open a person to make a diagnosis.

Risk
The source is as small as possible and the risks resulting from exposure to radiation is very small.

Radiotherapy
External radiotherapy is where the radiation comes from a machine outside the body. Internal radiotherapy is where the radiation comes from implants or liquids placed inside the body. The treatment is a radioactive source placed inside the body or needles are placed in the tumor.

Risk
To kill cancerous cells radiation used is closely controlled with it being as small as possible and the risks resulting from exposure to radiation is very small. Most side effects only last a few days or weeks but some of the effects of radiotherapy, such as tiredness, may continue for a couple of months after the end of your treatment.

Sterilisation of equipment.
High-energy gamma emitting ^{60}Co-radioisotope sources are used to sterilise plastic and rubberised instruments which could be affected if sterilised using high heat or chemicals.

Overall risk
There are strict limits to how much people can be exposed to radiation so as not to cause damage. Also sources are shielded with lead which the radiation cannot get through.

SAMPLE LEARNER WORK

Task 3 – Be able to measure energy transfers and calculate efficiencies

Your task is measure the efficiency of wind turbine in generating electricity
Wind is created by different areas of pressure in the atmosphere and air moves from one area to another.
The wind turbine will convert the kinetic energy of the wind passing over its blades to electrical energy.
A fan is used to produce the wind in the laboratory.

Energy conversions:

Kinetic energy of the moving air → Kinetic energy of blades → Generator coverts to electrical energy

So measure the wind energy in and compare it to the electrical energy out.

Method

1. Measure the length and width of one blade.
2. Connect a wind turbine to a multimeter.
3. Blow air over the turbine blades from a fan.
4. Measure the speed of the air.
5. Measure the current and voltage produced by the wind turbine on the multimeter.

Measurements

Blade is 0.10 x 0.01 metres

Area is Length x width
A = L x W

Area of blade is 0.001 but for 6 blades it is 0.006m2
Wind speed reads 4m/s on meter
Current (I) = 0.2A measured on multimeter
Voltage (V) = 0.9v measured on multimeter

Calculations

Energy in is kinetic energy of wind measured in Joules (J) is
= $\frac{1}{2} mv^2$
= $\frac{1}{2} A\rho v^3$

= ½ x area of blades(A) x density of air(ρ which is 1.2 kg/m^3) x wind speed three times(v)

Wind Energy in = ½ x A x ρ x v x v x v

= ½ x 0.006 x 1.2 x 4 x 4 x4
= 0.2304 J

Electrical energy out = Current x Voltage in Joules
= I amps x V volts (J)

Electrical energy out = I x V
= 0.2 x 0.9
= 0.18J

SAMPLE LEARNER WORK

Calculate the efficiency of the turbine changing the energy of the air into electricity

Efficiency of the wind turbine = $\frac{\text{Electrical energy out}}{\text{Wind energy in}} \times 100$

Efficiency of wind turbine is $\frac{0.18 \times 100}{0.2304}$ = 78.2%

Competency	MB1	MB2	MB3
Taking measurements			
Some support needed to choose correct equipment	✓		
Choose correct equipment			
Some help needed to set up the equipment	✓		
Set up the equipment			
Zero or calibrate apparatus	✓		
Some data recorded	✓		
Record result			
Recorded data to correct significant figures			
Correctly position eye when taking measurement			
Maintaining a safe and uncluttered working environment			
Most of the time	✓		
All of the time			
Rigorously and with prior thought and planning			
With support carries out risk assessment	✓		
Carries out risk assessment			
Following standard procedures			
With support follows basic standard procedures correctly	✓		
Follows basic standard procedure correctly			
Follows complex procedure correctly			
Makes own adaptations to standard procedure to improve reliability			
Note: Method given & Equations given (MB1)	✓		
Assessors signature: XXXXXXXXX Assessors name: XXXXXXXXXX Date:XXXXXXXX			

Teacher comment:

- Provided significant support with method and equipment set it up and to take measurements
- Provided equations – learner did substituted data correctly and carried out some calculations

SAMPLE LEARNER WORK

Task 4 – Designing a health education programme

The bosses of a football club are concerned that second team players are taking too much time off because of illness. Design a health education programme for them.

The problem

Some second team players may not play for the club year upon year, so they do not always have the motivation to keep healthy; this is shown by the number of these players who have been off ill.

The solution

Leaflets that will inspire them to look after themselves, I will use well known players to put the message across.

Cristiano Ronaldo

Avoid drugs and alchol

Alcohol is a depressant and will lead to bad judgment and coordination as well as distort your sight. You will not be able to pass the ball to the man.

Smoking cigarettes will lead to heart disease, stroke, and cancer and may lead to sleepiness, memory and concentration problems, impaired motor coordination and increased heart rate. You will run out of breath so not be able to run quickly to get into position.

Drugs will trouble your senses of direction, distance, and time. Also lead to drowsiness, mental slowness. You not be able to control the ball.

Smoking, drinking, taking drugs are the third biggest killers in the UK

All three are highly addictive
If you want to be a successful footballer think twice before indulging

SAMPLE LEARNER WORK

Lionel Messi

Eat a Balanced diet

To be the greatest goal scorer ever you need to be healthy, one way is to eat a balanced diet.

Eat starchy foods - potatoes, cereals, pasta, rice and bread.

Eat lots of fruit and veg - five portions a day

Fish is a good source of protein and contains many vitamins and minerals.

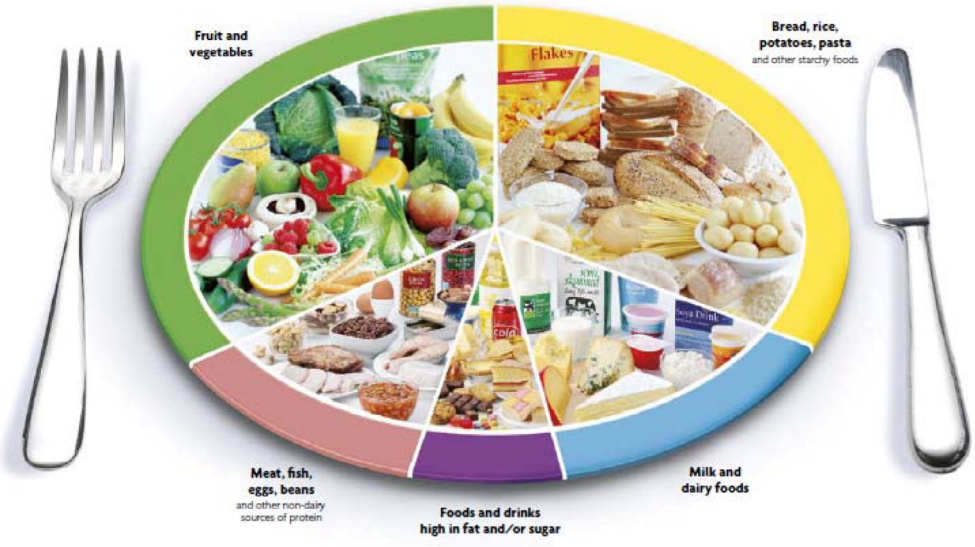
Cut down on saturated fat and sugar.

Eat less salt.

Don't get thirsty, drink about 1.2 litres of fluid every day.

The eatwell plate

Use the eatwell plate to help you get the balance right. It shows how much of what you eat should come from each food group.



Department of Health in association with the Welsh Government, the Scottish Government and the Food Standards Agency in Northern Ireland

SAMPLE LEARNER WORK

Benni McCarthy

Play football

Yes that's why you are here but there are times when you won't be playing or training so you need to keep yourself fit.

> Adults need to do two types of physical activity each week: aerobic and muscle-strengthening activity.

At least 150 minutes of moderate-intensity aerobic activity such as cycling or fast walking every week, and muscle-strengthening activities on two or more days a week that work all major muscle groups (legs, hips, back, abdomen, chest, shoulders and arms).

Or 75 minutes of vigorous-intensity aerobic activity such as running or a game of singles tennis every week, and muscle-strengthening activities on 2 or more days a week that work all major muscle groups (legs, hips, back, abdomen, chest, shoulders and arms).

Keep fit and healthy

SAMPLE LEARNER WORK

Task 5 – The benefits and risks of medical treatment

Produce materials to reassure worried patients on a treatment and testing

Kidney transplant

Problem

Your kidney filters your blood of waste products and then you get rid of the waste in urine. If your kidneys are damaged they do not filter as well and waste products can build up in your body and eventually poison you. This can be caused by

Diabetes – high blood glucose can damage your kidneys
High blood pressure strains the kidneys and so they don't filter as well.

When a kidney loses about 90% of its ability to filter then there is a serious medical problem resulting in a coma and death.

Treatment

There are two main treatment options when it is known kidney failure is likely to occur:

- dialysis, where a mechanical device is used to replicate the functions of the kidney.
- kidney transplant, which, if possible, is usually the preferred option because it is much less inconvenient than having dialysis.

Risk

However, kidney transplants, like any other type of surgery, there can be risks.

- Infections are common perhaps one in two people get a minor infection.
- Blood clots can sometimes form in the arteries or the arteries can narrow to the new kidneys.
- Sometimes the urine tubes from the kidneys get blocked or leak a little.

The main risk is rejection of the new kidney but this is overcome with drugs

Aftercare

People still need to look after themselves when they have had a kidney transplant.

- Give up smoking this will reduce kidney failure.
- Stay within the drinking guide lines to keep blood pressure down
- Eat a healthy balanced diet with reduced salt.
- Exercise and keep your weight down.

Clinical trials

To make sure that the procedure and the drugs taken are the best for example in kidney transplants clinical trials take place.
Before a procedure or medicines are given they are tested in the laboratory so it is safe for humans.
Studies in laboratory animals first to determine potential toxicity before they can be tried in people.

Then if it is safe it is tested on humans.
These tests are called clinical trials.

In human drug tests a blind trial is used this is when both the control group who take a placebo and the test group taking the medication do not know what they are taking. This prevents bias on how the groups are affected.

SAMPLE LEARNER WORK

In a double blind test both the subjects and researcher do not know who has been given the placebo or test medicine. The double blind test is the industry standard for testing pharmaceutical trails.

Statistics are also kept to see if any pattern occurs in a particular hospital, a particular surgeon or procedure and then can be acted on.

Task 6 – Practical procedures: measuring the environmental effects of human activity

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Following a change in traffic flow more traffic is passing by the school. From 8.00am to 6.00pm there is almost a continuous flow of cars past the main gates.
There is a noticeable increase in car fumes.
An environmental monitoring programme has been established.

Sample collected:

1. Leaves overhanging the road will be sampled for particulates. Sellotape will be used to take the particulates off the leaves.
2. Rain water will be collected in 15cm diameter glass jars. The fumes from the cars will be dissolved by the rain and so the fumes can be directly sampled from the rain water.
3. Cress seeds growing in petri dishes will be placed on the lower section of the wall. The cress will be a direct living indicator for the effect of the fumes.

Testing rain water

Method

- Add 5 ml of the pool sample to a test tube with a clean pipette
- Now add 5 ml of silver nitrate
- If a white precipitate forms then there is chloride present

Results

Test	Location 1	Location 2
Chloride	No – no precipitate formed	No – no precipitate formed

Method

- Add 5 ml of the Sample to a test tube using a clean pipette
- Then add 1 ml of barium chloride to the sample
- If a white precipitate forms then sulphate is present

Results

Test	Location 1	Location 2
Sulphate	Yes – a white precipitate formed	There was some as a slight precipitate formed

Method

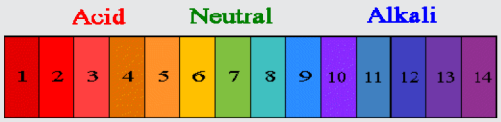
- Add 5 ml of the Sample to a test tube using a clean pipette
- Then add 1 ml of limewater to the sample
- If a white precipitate forms then carbonate is present

Results

Test	Location 1	Location 2
Carbonate	Yes – a white precipitate formed	There was some as a slight precipitate formed

Method

- Add 5 ml of the Sample to a test tube using a clean pipette
- Then add 1 ml of universal indicator to the sample
- Compare colour to colour scale



Results

Test	Location 1	Location 2
Acidity	pH5	pH6

Testing cress seeds

Method

- Add 20 cress seeds into each dish. Make sure they are spaced out.
- Leave for 1 week.
- Count the cress seeds that are healthy in each sample.

Results

Location	pH of location	Number of healthy cress seeds out of 20 planted
1	5	13
2	6	20

SAMPLE LEARNER WORK

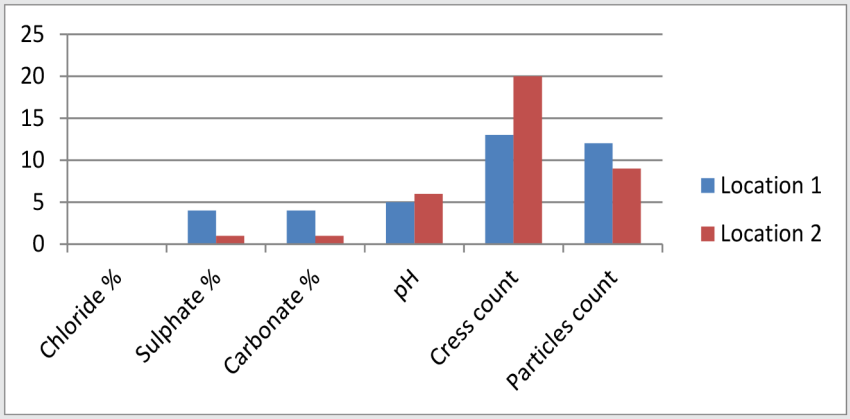
Microscopic particulate count

Method

- Press sellotape onto leaf surface
- Cut 1 cm^2 piece and place onto a slide
- Examine slide under microscope
- Count the particulate
- Estimate the size of the particles

Results

Location	Number per cm^2	Size range mm
1	12	0.5 to 1.0
2	9	0.5 to 1.0



Comparison of data between location 1 and location 2

Report

There was more pollution at location 1 than location 2. But there was pollution at both locations. Fumes were producing sulphur dioxide and carbon dioxide and giving off soot.

SAMPLE LEARNER WORK

Competency	MB1	MB2	MB3
Taking measurements			
Some support needed to choose correct equipment	✓		
Choose correct equipment			
Zero or calibrate apparatus			
Some data recorded	✓		
Record result			
Recording data to correct significant figures			
Correctly position eye when taking measurement			
Maintaining a safe and uncluttered working environment			
Most of the time	✓		
All of the time			
Rigorously and with prior thought and planning			
With guidance carries out risk assessment	✓		
Carries out risk assessment			
Linking test to require results			
Little linkage of the chosen tests to the substance			
Linkage of the chosen tests to the substance	✓		
Full linkage of the chosen tests to thesubstance			
Following standard procedures			
With support follows basic standard procedures correctly	✓		
Follows basic standard procedure correctly			
Follows complex procedure correctly			
Makes own adaptations to standard procedure to improve reliability			
Assessors signature: XXXXXXXXX Assessors name: XXXXXXXXXX Date:XXXXXXXX			

Teacher Comments:
Choice of measurements given.
Provided method and equipment.
Support was given to set up equipment.

Task 7 – The environmental impact of materials used in house building

A range of materials used in the construction of a new house and the environmental impact of the production of the materials from natural resources.

Materials used in construction of a house		
Construction	**Materials**	**Lessen impact on environment**
Joist	• Pine • Chipboard • Plywood	Buildings with wooden structures lower the processing energy, also using wood can be almost carbon neutral, if the wood was recycled and reused at the end-of-life.
Fittings	• Door handles • Locks • Screws • Nails • Hinges • Nuts and bolts	Recycling - construction materials can be reused and recycled, such as: iron, steel copper. Producing steel using scrap steel reduces emissions by three-quarters, compared with producing the same amount of primary steel.
Window	• Glass	
Wall	• Bricks • Natural stone • Concrete • Plasterboard • Cement	Bricks made from local clays and renewable constituents, such as straw, have lower environmental impacts compared with conventional bricks. The energy needed to make clinker to make cement is high also carbon dioxide given off in large amounts both have a major environmental impact. Emissions could be halved if renewable sources of energy and improving technologies were used.

SAMPLE LEARNER WORK

Materials used in construction of a house		
Construction	**Materials**	**Lessen impact on environment**
Roof	• Slates • Clay tiles	Making roof tiles out of concrete is a better option than using either ceramic or fibre cement roof materials. Concrete tiles are better as they save half of the energy needed to process them compared to ceramic roof tiles. Ceramic tiles are better than fibre cement roof tiles as they save half of the energy used in processing them.
Floor	• Timber • Tiles • Concrete	The use quarry tiles is better than of ceramic tiles in flooring as quarry tiles saving manufacturing energy and a cutting down emissions.

Production process	**Raw materials**	**Reaction**	**Impact on environment**	**Alternative process**
Extracting iron using a blast furnace	iron ore, limestone coke	Iron oxide + carbon monoxide > Iron + carbon dioxide	Loss of land due to mining. Air pollution - carbon dioxide gives the greenhouse effect, sulphur dioxide gives acid rain. Disposal of slag Transport of materials.	Hismelt is a direct smelting process, iron is produced with no slag The process allows iron ore with significant impurities to be used, and cheaper non coking coal instead of coke.
Limestone to make cement	Limestone sand shale clay iron ore	Calcium carbonate > Calcium oxide + carbon dioxide	Heavy traffic. Quarrying. Destruction of the habitats of animals and birds.	Use of renewable fuels when heating.

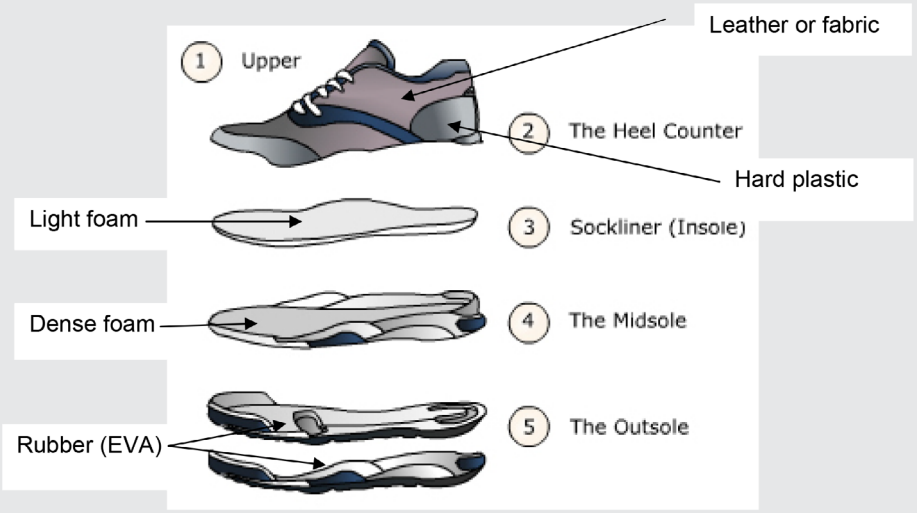
SAMPLE LEARNER WORK

Task 8 – How the properties of materials used in manufacturing a car are determined by structure and bonding

You should identify a range of solid materials used in a manufacturing a trainer. You should explain why they are used and how the structure and bonding of these materials makes them suitable.

Teacher Comment:
Significant support has been given to identify the materials in a complex product, the trainer.

Parts of a sports trainer



Part	Properties needed	Reason for Use
Upper	Flexible Water proof Breathable	Allow foot to move Keeps the foot dry Stops the shoe from smelling
Heel counter	Rigid	Gives support to the heel
Sockliner	Moulded Soft	Supports foot arch Cushions foot
Midsole	Shock absorbent	Cushions foot from stamping
Outsole	Gives traction Hard wearing Slightly flexible	Gives grip In contact with ground so it is not worn away Allows for running

Materials used in a trainer

Adidas - Adiprene
Adiprene is an elastic material which cushions the moving foot and is generally used in the heel. Adiprene is a polyurethane rubber a polymer made by polymerisation.

Nike - Thermoplastic urethane (TPU)
Used in the midsole to provide durable cushioning.
It is a plastic material which can be repeatedly softened and remoulded by heat, but which retains its form at normal temperatures.

SAMPLE LEARNER WORK

Full-grain leather
Full-grain leather is the strongest, durable form leather and is used in the upper part of trainers. It is a natural material from the skin of cows.

Neoprene
Is a synthetic rubber and is used in sole

Performance of materials in a sports trainer

Material	Resistance to Weathering	Resistance to Corrosion	Resistance to Wear
Nylon	High	High	Very High
Polythene	High	High	High
Polyester	High	High	High
Rubber	High	High	Very High
Linen	Low	Low	Low
Denim	Low	Medium	Low
Leather	High	Medium	Medium

Based on results from Task 9

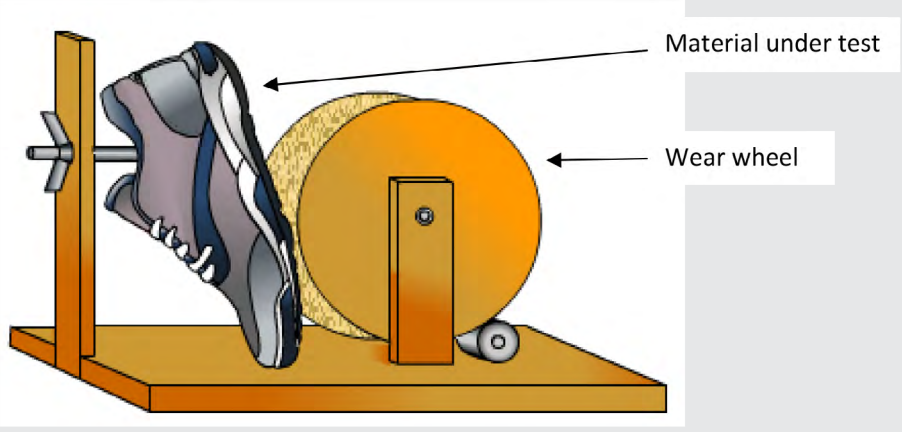
Task 9 – Measuring the properties of materials

Carry out scientific tests on a range of materials used for a sports trainer to decide which is the best to use.
Teacher comment:
Provided method and equipment.
Help to set up equipment.
Provided the mathematical techniques to use.

I will test various materials to find which material would be best to use in the sole of a sports trainer.

Resistance to Wear

I will test the wear by:
Measuring the time to wear a 1mm depth wear of material when placed on a wear wheel.



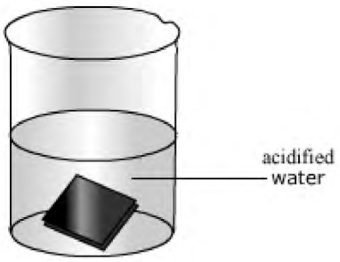
Results

Material	Time to wear 1mm depth (s)
Nylon	9
Polythene	7
Polyester	7
Rubber	8
Linen	2
Denim	2
Leather	4

Nylon is more hard wearing than :
Rubber 9/8 which is 1.13 times
Polythene and polyester by 9/7 which is 1.29 times
Leather by 9/4 which is 2.25 times
Linen and denim 9/2 which is 4.50 times

Resistance to Corrosion

I will soak the material for short periods in beakers containing a weak solution of sulphuric acid to test for corrosion.



The section of trainer sole is placed in a beaker of water (simulating rain, washing etc.) for a set time.

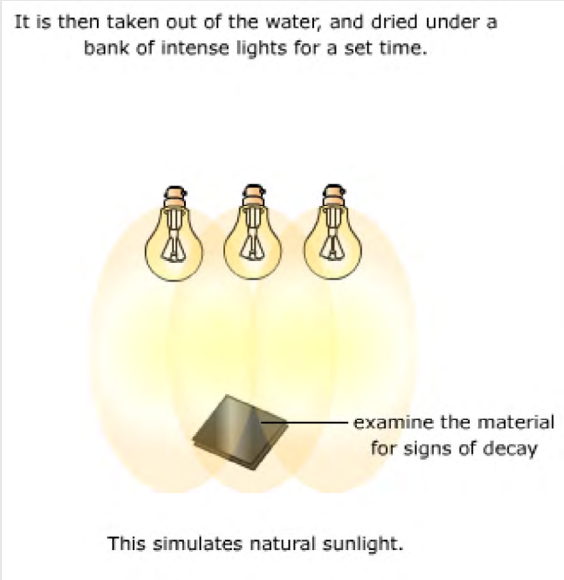
Results

Material	Resistance to Corrosion
Nylon	High
Polythene	High
Polyester	High
Rubber	High
Linen	Low
Denim	Medium
Leather	Medium

SAMPLE LEARNER WORK

Resistance to Weathering

I will soak the material in 250ml of water for 24 hours then placing the material under a bank of lights for 24 hours.



Results

Material	Resistance to Weathering
Nylon	High
Polythene	High
Polyester	High
Rubber	High
Linen	Low
Denim	Low
Leather	High

Summary of results

Material	Resistance to Weathering	Resistance to Corrosion	Resistance to Wear
Nylon	High	High	Very High
Polythene	High	High	High
Polyester	High	High	High
Rubber	High	High	Very High
Linen	Low	Low	Low
Denim	Low	Medium	Low
Leather	High	Medium	Medium

The best material would be Nylon or Rubber as they both had:
High resistance to weathering, corrosion and a very high resistance wear.

SAMPLE LEARNER WORK

Competency	MB1	MB2	MB3
Taking measurements			
Some support needed to choose correct equipment	✓		
Choose correct equipment			
Zero or calibrate apparatus			
Some data recorded	✓		
Record result			
Recording data to correct significant figures	✓		
Correctly position eye when taking measurement			
Maintaining a safe and uncluttered working environment			
Most of the time	✓		
All of the time			
Rigorously and with prior thought and planning			
With guidance carries out risk assessment	✓		
Carries out risk assessment			
Linking test to require results			
Little linkage of the chosen tests to the function of the material	✓		
Linkage of the chosen tests to the function of the materials			
Full linkage of the chosen tests to the function of the materials			
Following standard procedures			
With support follows basic standard procedures correctly	✓		
Follows basic standard procedure correctly			
Follows complex procedure correctly			
Makes own adaptations to standard procedure to improve reliability			
Assessors signature: XXXXXXXXX Assessors name: XXXXXXXXXX Date:XXXXXXXX			

Learning Objective 1 - Be able to analyse personal and social choices related to energy supply

Marking commentary on MB1 sample learner work

Different energy sources have been listed with advantages and disadvantages which shows a basic understanding in the choice of energy source. Quantitative efficiencies have been given but the analysis is very limited. Main concerns of householders have been listed but with no explanations. Votes taken but again no explanation as to why people voted as they did. The evidence meets top/middle criteria for MB1.

Suggested improvements to progress sample learner work to MB2

A list of five energy sources has been given, for MB2 at least six are required. With the five sources simple descriptions have been given which support a basic understanding when making a choice of an energy source; this has been expanded on by a survey of householders, the interest group. For MB2, descriptions of the energy sources need to display a greater scientific understanding from which a choice can be made. It is expected that some quantitative data would also be used when making a choice at MB2. There is only limited qualitative analysis of efficiencies of energy transfer in electricity generation at MB2 there has to be a quantitative analysis of at least two sources.

Learning Objective 2 - Understand the risks and benefits related to the applications of nuclear radiation

Marking commentary on MB1 sample learner work

Applications in healthcare have been identified with simple health descriptions with some justification.

Suggested improvements to progress sample learner work to MB2

Four uses in healthcare have been given with both benefits and risks so showing a simple justification for the use. For MB2 three or four beneficial uses for two tasks are required.
Named isotopes have been given, this would be expected at MB2 not MB1.

Learning Objective 3 - Be able to measure energy transfers and calculate efficiencies

Marking commentary on MB1 sample learner work

Context - efficiency of energy transfers in a wind turbine. Witness statement supports that when provided with method and equipment, support needed to set it up and to take measurements. All (not just some) measurements were taken and recorded and all calculations carried out correctly, so at top of MB1.

Suggested improvements to progress sample learner work to MB2

The teacher has commented on the support – providing method and setting up the equipment, as well as providing the equations. At MB2 the same investigation can be carried out but the learner needs to show greater independence, they have to select the equipment themselves and then set it up with as little support as possible from the teacher. They also have to select the correct equations themselves but can be helped when manipulating them.
The learner has substituted in the correct data and got the correct answer from the calculation this too is expected at MB2.

Learning Objective 4 - Understand how human health can be improved

Marking commentary on MB1 sample learner work

Context – footballers who are not playing but still need to keep fit. Images sit well within the context. There is qualitative data on the impact but description and range is limited so towards top of MB1.

Suggested improvements to progress sample learner work to MB2

Three brief leaflets have been produced with relevant information but limited. Three factors that affect health have been given with qualitative statement on the impact of the three factors but not focused on a client group they are general statements. At MB2 it is expected that three to four factors are described in greater detail with some quantitative data on the impact such as about 100,000 people in the UK die each year.
Some suggestions have been given on a healthy diet and exercise but they are general and not directed at footballers. For MB2 both the effect of the factors and the health programme should be focused on the chosen client group.

Learning Objective 5 - Understand the risks and benefits of medical treatments

Marking commentary on MB1 sample learner work

There is a basic explanation as to why a treatment (kidney transplant) is needed with risks. The candidate goes onto to explain why there is a need for the testing of medical treatments.
Within MB1 as the analysis of risk is limited to a list and clinical trials is simply explained.

Suggested improvements to progress sample learner work to MB2

Only one treatment needs to be addressed for all MBs. Risks and benefits of a medical treatment have been listed but there has not been a Simple qualitative analysis of the risks and benefits as required for MB2.
A simple reason has been given for testing but greater reasoning is required and laboratory testing, animal testing and blind testing must also be included at MB2.
The information given does lack a format; this presentation would not be seen in a doctor's waiting room.

Learning Objective 6 - Be able to measure the environmental effects of human activity

Marking commentary on MB1 sample learner work

Supported by witness statement. Support given throughout. Physical/chemical factors of the ecosystem were measured; plants and animals that live in the ecosystem were not measured so there was a limitation to the investigation but some data was collected and recorded and the investigation is valid and very apt. So within MB1 and expertise towards middle/top.

Suggested improvements to progress sample learner work to MB2

The teacher comment states that they choose which measurements to take and no independence was shown by the learner. At MB2 independence must be shown when choosing the measurements and how the sampling and testing will happen although some help may be given when setting up the equipment.
At MB2 at least 1 set of data from biotic and abiotic sampling must be collected so it is expected two sites are selected and then the results analysed for MB2.
A range of relevant data might be expected to have repeat measurements for each test at each site, this was not done.
Two sites have been used but a simple qualitative statement has been given as an analysis and no simple calculation such as frequency has been made which is required at MB2.

Learning Objective 7 - Understand how materials we use are made from natural resources

Marking commentary on MB1 sample learner work

Different materials used for house construction were listed with a very limited description as how the impact on the environment could be reduced.
Two chemical processes, using of word equations with alternative production methods suggested which would have a lower environmental impact.
The range of evidence is correct but limited and is towards middle of MB1.

Suggested improvements to progress sample learner work to MB2

A range of six building materials have been categorised at MB2 it is expected to be up to seven.
Two chemical processes have been given with a word equation but at MB2 some use of symbol equations and chemical nomenclature needs to be included with at least processes yield calculated. Simple qualitative statements rather than quantitative analysis on the impact of production with alternative production methods stated rather than evaluated as needed for MB2.
Overall the learner has tended to quote information rather than to analyse information as needed in MB2.

Learning Objective 8 - Understand how the properties of materials we use are determined by structure and bonding

Marking commentary on MB1 sample learner work

Leaning objective 8 has been linked to learning objective 9.
Limited support needed to identify some different types of materials was stated in the teacher's record; simple reasons for their use were listed.
A limited description of the properties of selected materials but not their structures given.
Qualitative information on the properties of materials came from learning objective 9.
Evidence is at middle MB1.

Suggested improvements to progress sample learner work to MB2

Significant help has been given to identify the materials in the trainer, at MB2 only a limited amount is permitted. It is expected that for MB1 a range of 2 materials at least and for MB2 a range of 3/4 materials should be identified.
Properties have been linked to their use but there is no link to how these properties depend on their molecular bonding and structure as needed in MB2.
There has been linkage to learning objective 9 to give qualitative information on the properties of the materials but no quantitative data as needed in MB2.

Learning Objective 9 - Be able to measure the properties of materials to recommend appropriate uses

Marking commentary on MB1 sample learner work

Learning objective 9 is linked to learning objective 8 and is supported by a witness statement.
With support the practical tests were correctly carried out with the necessary measurements taken and clearly recorded. No mathematical techniques required. A simple conclusion given.
Towards the top of MB1.

Suggested improvements to progress sample learner work to MB2

For all MBs at least 2 materials tested for at least 2 properties which have been done.
Teacher comment indicates that help was given in the method, selecting and using the equipment for MB2 independently has to be shown although there can be a little help setting up the equipment. Some simple measurement have been taken and recorded.
A simple mathematical technique of division and correct rounding of values has been used. A simple technique at MB2 could include calculating percentage error, percentage yield, substitution in an equation or calculation of the surface area of a simple shape.

Sample Learner Work Marking Band 3

SAMPLE LEARNER WORK

Task 1 – Analytical task: Choosing an energy supply

Research on Energy Sources that will generate electricity

Before choosing an energy source for my location I will gather information on a range of energy sources.

Wind Energy

Wind turbines convert the kinetic energy from the wind into mechanical energy which is then used to drive a generator that converts this energy into electricity.

The average turbines today is around 2.5-3 MW, with blades of about 50 metres length. It can produce energy more than 1,500 average households.
Whereas an average offshore wind turbine of 3.6 MW can power more than 3,312 households.

Wind turbines require roughly 0.1 square kilometres of unobstructed land per megawatt of electricity production. A 2 GW wind farm, which might produce as much energy each year as a 1 GW might have turbines spread out over an area of approximately 200 square kilometres.
Construction time is usually very short – a 10 MW wind farm can easily be built in two months. A larger 50 MW wind farm can be built in six months.

The amount of power transferred is directly proportional to the density of the air, the area swept out by the rotor, and the cube of the wind speed.
The power P available in the wind is given by:

$$P = \tfrac{1}{2} \rho \pi R^2 v^3$$

A wind turbine can extract at most 59% but on average 35% of the energy that would flow through the turbine's cross section as the wind speed can change from day to day.

For maximum efficiency, turbines require a smooth flow of air over the rotor blades at a constant speed.
The usual wind range for successful electrical generation is 8 to 25 mph. Above these speeds turbines have to be "switched off" to stop them being damaged below these speeds the mechanical efficiency of the turbine is such it cannot generate electricity.

Other general benefits are:

- Because it uses energy already present in the atmosphere, it does not require the burning of fossil fuels so wind power does not product greenhouse gases.
- While wind turbines might impact the numbers of some bird species, conventionally fuelled power plants could wipe out hundreds or even thousands of the world's species through climate change, acid rain and pollution. In the UK, where there are several hundred turbines, about one bird is killed per turbine per year; 10 million per year are killed by cars alone.
- Wind energy is one of the safest energy technologies; in over 20 years of operating experience and with more than 50,000 machines installed around the world, no member of the public has ever been harmed by operating wind turbines.

Disadvantages are:

- Turbines are sited in locations that are visible from miles around being 300m tall with rotor diameters of 100m and so some people think they are visually intrusive
- Turbines produce noise, wind farms add 80-110dB which can annoy people living close by.
- Turbines can also have red flashing lights to warn aircraft of their location, these lights can be seen from far distances and can be annoying to local communities.

Farms need a very large capital outlay to build them and can go through long, involved planning processes because of their impact on the environment, aviation, and wildlife as well as how they look to the local community.
There will be greater initial costs in building offshore but overall offshore wind farms may be the viable option due to a more useable and dependable source of wind, also less environmental impact to local communities.

At present Wind energy can supply the annual electricity demand of 4.7 million homes.
Large scale wind turbine farms on and offshore will become a major supplier of electricity to the national grid in the next twenty years.
For example the London Array, that is to be built in the outer Thames estuary, will have a capacity to generate 1,000 MW of electricity from 271 turbines and will supply the power for a quarter of the homes in Greater London.

Solar Energy

Solar energy can be provided by photovoltaic cells which are made from layers of semi-conducting material such as silicon. When light shines on the cell it creates an electric field across the layers. The stronger the sunshine, the more electricity is produced. Groups of cells are mounted together in panels or modules that can either be mounted on your roof or on the ground.

A 4kWp system that can be sited on a house roof can generate around 3,800 kilowatt hours of electricity a year the equivalent to a typical household's electricity needs. It will save nearly two tons of carbon dioxide every year.
5 acres of land is required for every 5 megawatts (MW) of installation, enough to power 1,515 homes. A wide range of land types can be used from rough farm land to brown sites, disused aerodromes and house roofs.

JAGUAR Land Rover has a rooftop solar system fixed to the roof of the Engine Manufacturing Centre. The system has 21,000 photovoltaic panels which will produce 5.8MW with plans to increase this to 6.3MW. The system will generate more than 30% of the Engine Manufacturing Centre's energy requirements. This is the equivalent to the energy needed to power more than 1,600 homes. The photovoltaic panels will reduce the plant's CO2 footprint by over 2,400 tons per year.
Other areas that might not be used for housing due to noise or other reasons can be ideal. Such as next to an airport; Bournemouth Airport has approval for a 120 acre site to have a 20MW solar farm which will produce enough energy for 5,000 homes.

Other general benefits are:

- There are no moving parts, and so maintenance is minimal; the panels do need to be kept clean of dirt so to maximise their efficiency.
- There is no by-product or waste generated, except during manufacturing. Companies are exploring the use of recycled materials in the production of panels so reducing the need for the use of new material for production.
- They have lower visual and environmental impacts than other forms of power generation as they are low to the ground and so are not in the general eye-line or blend in with roofs they are sited on.
- The energy produced gives the householder greater control on their use and so the cost rather than reliance on a "centrally" produced energy source which is controlled by a large organisation looking for profit.

The major disadvantage is the reliance on the climate and the amount of sunlight for the location.
For most of the UK there are approximately 4 to 5 peak sun hours in the summer reducing to 1 hour in winter. 1 m^2 of PV module will produce 700 to 800 kWh of electricity per year.

SAMPLE LEARNER WORK

Hydroelectricity

Electrical energy is produced by placing turbines in a flow of water. The turbines use the kinetic energy of the flowing water and converts it to mechanical energy. This causes the turbines to rotate at high speed, driving a generator that converts the mechanical energy into electrical energy.
The amount of hydroelectric power generated depends on the water flow and the vertical distance the water falls through.

The total hydroelectric installed capacity in the UK at the end of 2011 was approximately 1676 megawatts, which is around 1.9% of the current total UK generating capacity and 14% of renewable electricity generation capacity most of which comes from large-scale schemes in the Scottish Highlands.

There are 3 main types of hydroelectric schemes in use in the UK:
- Storage schemes where a dam holds water in a reservoir from which the water falls over a turbine to produce electricity.
- Run-of-river schemes use the natural flow of a river over a turbine. A weir can enhance the flow and then the water is channeled to the turbine.
- Pumped storage incorporates two reservoirs. At times of low demand, generally at night, electricity is used to pump water from the lower to the upper basin. This water is then released to create power at a time when demand, and therefore price, is high; pumped storage is very good for improving overall energy efficiency.

Hydroelectric energy plants have energy conversion efficiencies of 90% and above.

However large scale schemes are now limited, not only because of environmental concerns but also because many of the most economical sites have already been used.
The move now is small-scale hydro schemes used in a sustainable way. Some old watermills are also being refurbished and brought back into the energy supply network.
It is estimated there is a potential of 850 to 1550 megawatts in the UK which approximately 1 to 2% of current UK generating capacity and so would make a small contribution to UK renewable energy and emission reduction targets.

Other general benefits are:
- renewable but there is limited number of suitable reservoirs where hydroelectric power plants can be built and even less places where such projects are profitable.
- nonpolluting, the only pollution occurs during the construction
- reliable if the site is chosen correctly for climatic conditions.
- flexible as water flow can be adjusted and so the electricity output for when power consumption is low.

Disadvantages are:
- environmental consequences produced by damming of water, changed water flow and the construction of roads and power lines
- fish habitats can be greatly affected as they are dependent on physical factors such as water level, water velocity, shelter opportunities and access to food
- expensive to build and times decades to recoup the initial investment costs.

Wave and Tidal Energy

Wave and Tidal use the power from the movement of large amounts of water that is not confined.

Technologies being explored are:
- pressure differences under wave crests to drive water flows through turbine chambers,
- floating buoys that use the kinetic energy of the buoy's rise and fall to drive a turbine, and
- using the motion of joints in an articulated structure to drive hydraulic rams that power motors
- oscillating compressed air columns.

The British coastline is 11,072 miles long and has some of the highest tidal ranges in the world. The tidal range in the Severn Estuary that creates the Severn Boar can be as much as 50 feet (15.4 metres), the second highest in the world.

The amount of power in a wave is large with around 30 to 40kW for every metre length of a wave hitting the shore with up to 100kW per metre length out at sea.
When converting tidal energy the efficiency can be up to 80% however the energy can be seasonal with twice as much energy in a winter wave as to a summer wave.

A wave farm covering less than 0.5 square miles of ocean could generate 30MW enough for 20,000 homes.

The UK is trying out this energy source and has one large-scale marine energy installation supplying the national grid: a 1,200kW tidal turbine situated in Strangford Narrows, Northern Ireland. This turbine can generate up to 10,000kWh per tide, totaling about six million kWh a year.

The UK is also considering a tidal barrage across the Severn estuary, from Cardiff to Weston-super-Mare, which could produce up to 15.6 million kWh a year and could supply up to 5% of the UK's electricity demand.

Disadvantages are:
- the location is limited to the shore line and out to sea which has to be close enough for connection and maintenance. This will result in a visual problem as most of these areas would be used for tourism
- initial cost is very high as this is in the development stage
- high maintenance due to the power of the sea.

Energy from Biomass

Biomass is organic matter from plants and animals. Photosynthesis stores energy in plants and animals get energy from eating plants. Waste material from plants and animals which still contains energy can be burnt to release energy. This energy can then produce steam which is used to produce electricity.

It is a renewable source of energy as it is produced initially from crops. Renewing takes the time to grow and gather the crop.
It is seen as carbon neutral as carbon released in burning is eventually used in the action of photosynthesis when producing the next crop.
It is cost effective when compared to coal being about a 1/3 of the cost to produce the same amount of heat.
Biomass can be converted into methane gas and then be easily piped to the location it is needed.

However the extraction of biomass can be expensive when all the processes need for its production such as growing, harvesting and storage are taken into consideration and these processes require a large amount of space.

SAMPLE LEARNER WORK

The UK Government supports energy from waste if it is value for money and makes a cost effective contribution to UK environmental objectives.
In 2010 the combustion of the biodegradable component of waste provided 6.2% of the UK's total renewable electricity generation.

Steven's Croft is the biggest biomass plant in Scotland produces a total power of 44MW enough electricity to power the equivalent of 70,000 homes every year at a cost £90m.

Drax Biomass Heron Renewable Energy Plant located in South Humber Bank industrial area, provides 290 Megawatts enough electricity for up to 512,000 homes and uses around1.4 million to 2.5 million tonnes per year of biomass fuel.

Energy from Fossil Fuels
Fossil fuels (coal, gas, oil) are burnt in power stations to provide steam The useful kinetic energy in the steam is used to turn turbine blades connected to an electricity generator.

The major problem from burning fossil fuels is the emissions. Emissions from burning coal are carbon dioxide (CO2), sulphur dioxide (SO2), oxides of nitrogen (NOX), hydrogen chloride (HCl), and particulates (dust). These harmful gases can cause acid rain and also produce global warming. Acid rain damaging trees, and killing aquatic plants, fish and animals that rely on these. Huge amounts being released by both developing and developed countries.

A1000 MW coal-fired power station makes 7 000 000 tonnes of CO2 and 200,000 tonnes of sulphur dioxide per year. In addition it makes about 200 000 tonnes of soot or particulate matter which contains toxic chemicals.
Huge amounts of water are needed for the steam and to cool the steam. This results in unsightly concrete cooling towers. The hot steam can warm nearby water and disrupt the environment.
Also fossil fuels are not renewable as we are using them far faster than the millions of years they take to form. Coal in the UK is estimated to run out in 15 years, and gas in 20 years. This makes us increasingly dependent on other countries for our power. The Middle East is rich in oil, but is an unstable area at the moment.

However alternative fuels are being used such as shale gas from fracking. This is producing a large cheap source of energy.

The Government is going ahead with building of two new power stations as the technology has advance to reduce emissions and that the cost of the energy is low so contributing to the prosperity of the nation.

About 35% of the UK's electricity is still generated from coal.
The largest coal-fired power station in Europe is Drax in Yorkshire produces 4,000 megawatts of electricity enough to supply electricity to 4 million homes.

Drax's generating units have all been retrofitted with Flue Gas Desulphurisation (FGD) equipment which removes at least 90% of SO2 and HCl emissions before the flue gas is released via the chimney into the atmosphere.
The majority of ash produced at Drax is sold to the construction industry with the remainder sent for landfill at the power station's adjacent Barlow Mound ash disposal site, which over time has been developed into farmland, woodland and wetland features providing a haven to many species of wildlife and birdlife.

Nuclear Power

The heart from nuclear fission is used to produce steam to drive turbines in the generation of electricity.
The UK currently has 10 nuclear power stations, which provide approximately 20% of the country's electricity.

Nuclear power will help the UK to
- meet decarbonise and meet legal low-carbon obligations
- benefit the economy more widely
- produce large quantities of low carbon electricity over an extended period.

The Government considers that the risk of health from the building and operation of new Nuclear power stations is very low:
- radiation dose which the public would receive would be below detectable risk levels
- safety features in design will keep gaseous and aqueous emissions to a minimum
- risk of accidental release of radioactive will be reduced and mitigated.

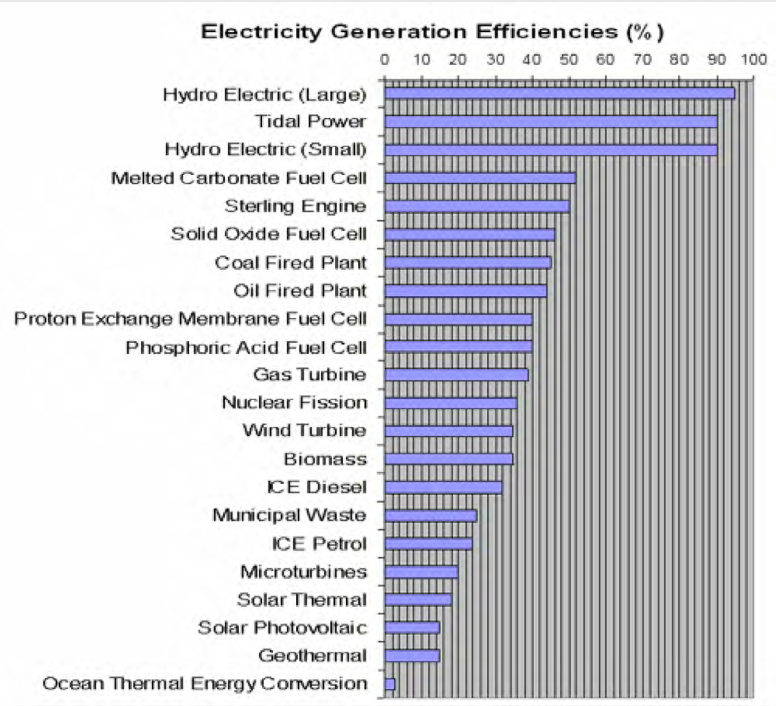
However:
Nuclear power stations accidents can cause dangerous radiation to escape, devastating surrounding land and threatening human and animal life, as happened in 1986 at Chernobyl in the former Soviet Union.

Nuclear power stations require decommissioning (after 40-50 years) the waste has to be stored for hundreds of years until the radioactivity has reduced to safe levels. Decommissioning is therefore a very expensive activity.

Geothermal Energy

Geothermal energy generates electricity from natural hot water pumped up from holes drilled under hot areas beneath the surface. These hot areas tend to be near volcanic areas and igneous intrusions.
So the production of electricity by this source is very limited and unreliable although it is non-polluting and cost are low.

Choice of energy source will depend on their efficiency when compared to each other.



SAMPLE LEARNER WORK

The most efficient source is hydroelectrical at 95% efficient with coal fired plants at 45%, nuclear power at 36%, wind at 34% and solar PV at 18% (although this efficiency is set to increase with future developments).
So hydroelectrical is over x2 more efficient than coal powered plants and approxiamately x3 more efficient than nuclear and wind energy and about x4.5 more efficient than solar energy.

Overall efficiency will also depend on Electricity Distribution Efficiency

The resistance of the cables conducting the current flow between the generating plant and the end user's premises cause further efficiency losses due to the Joule heating (I^2R Losses) of the interconnecting power cables. There are two major influencing factors.

Location
The resistance of the cables increases with distance so that losses are typically 5% for supplies to urban locations close to the power source but as high as 10% to 20% for remote rural locations.

Cables
There are three types of energy loss:
- the Joule effect, where energy is lost as heat
- in the conducting wire
- magnetic losses, where energy dissipates into the dielectric effect, where energy is absorbed in the insulating material.

Heating losses are proportional to the square of the current, distribution losses can be reduced by transmitting the power with as low a current as possible by using higher transmission voltages.

The upper voltage limit is set by the breakdown of the air insulation between the power cables and the earth, or more likely across the insulators suspending the cables from the transmission pylons.

With high voltage transmission systems there are also additional, though minor, copper and iron losses in the transformers, stepping up the voltage at the generating station and stepping it down again at the point of consumption, due to the resistance of the windings and eddy current losses in the transformer cores.

The Joule effect in transmission cables accounts for losses of about 2.5% while the losses in transformers range between 1% and 2%.

So, saving just 1 % on the electrical energy produced by a power plant of 1000 megawatts means transmitting 10 MW more to consumers, which would supply 1000 - 2000 more homes.

The use of renewable will alter over time due to a number of considerations.

The total generation from renewables in the half of 2013 was 12.83 TWh.

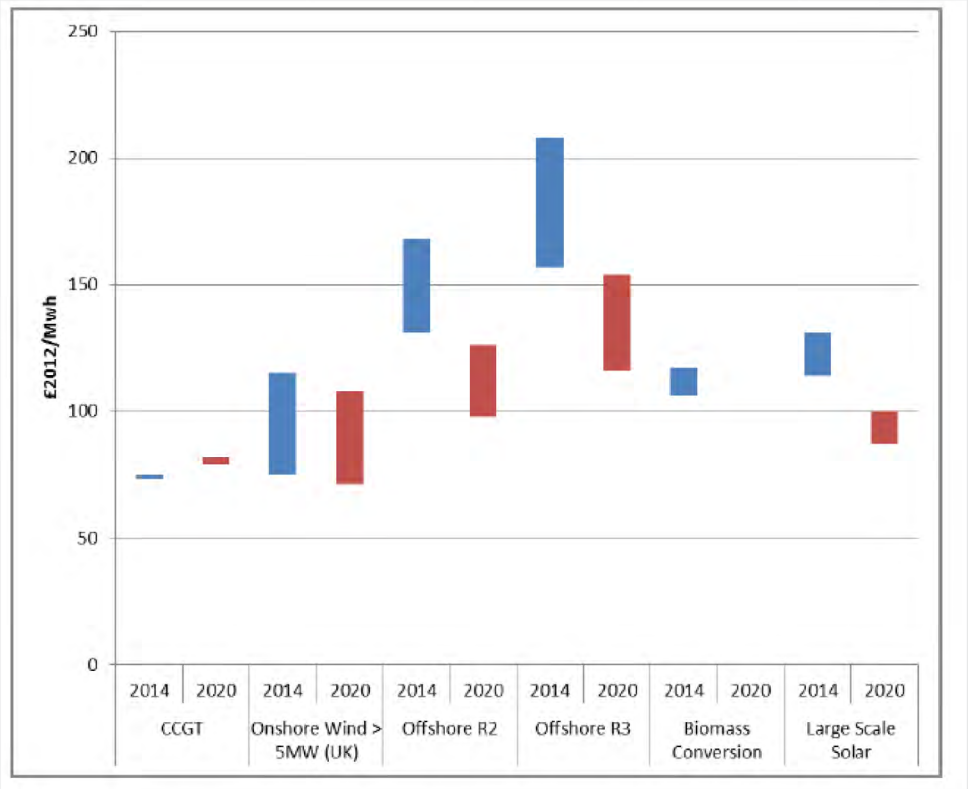
Generation from bioenergy increased by 58%, partly as a result of two new conversions of coal stations to dedicated biomass.
Wind generation increased by 62% due to increased onshore and offshore capacity and high wind speeds.

Electricity generation from renewable sources for the period July 2012 to June 2013 was 47.5 TWh, increasing by 24% compared to the same period the year before.

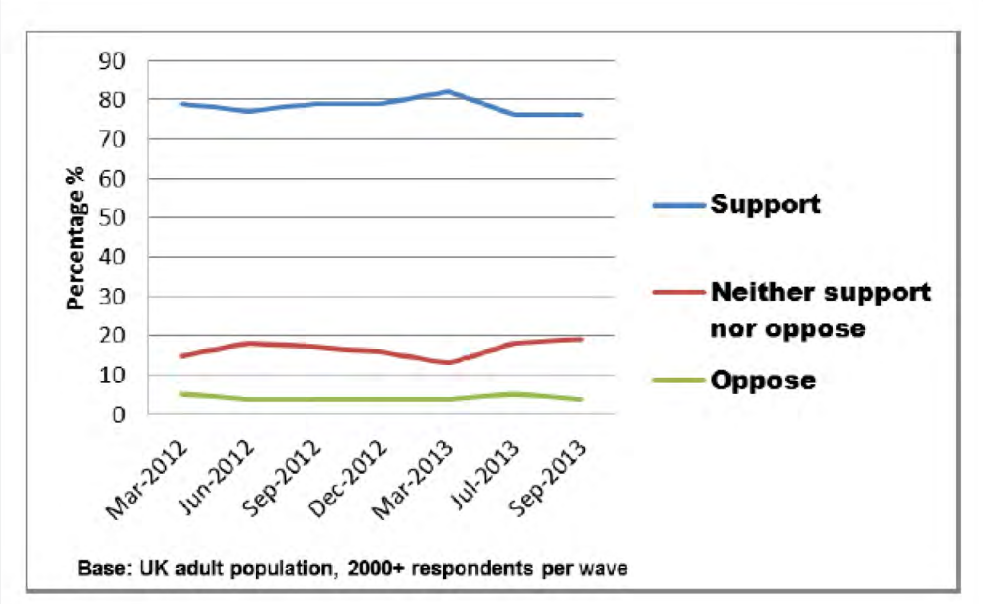
Cost is a major consideration, the Government highlights the levelled cost of electricity generation for selected technologies using technology specific hurdle rates.
It shows (where applicable) the levelled costs for plants commissioning in 2014 and 2020.

Coal powered stations will be x1.3 cheaper than onshore wind and approximately x1.8 cheaper than offshore wind but only x 1.2 cheaper than solar.

SAMPLE LEARNER WORK

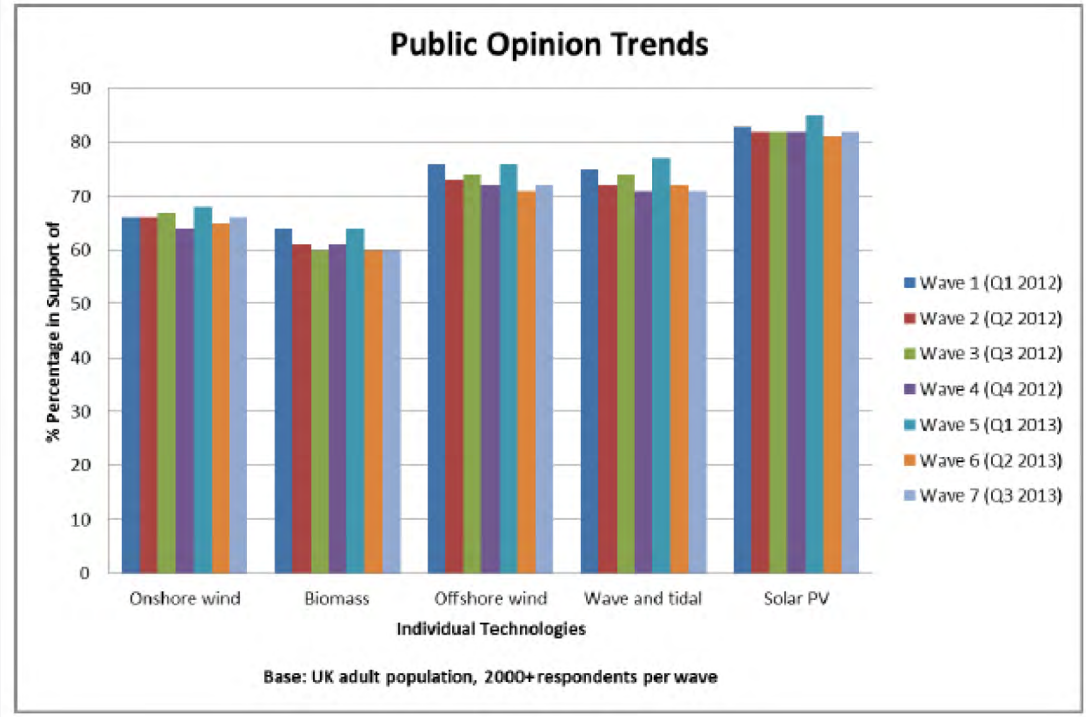


But Government poling still sees consistently high levels of public support for the use of renewable energy.

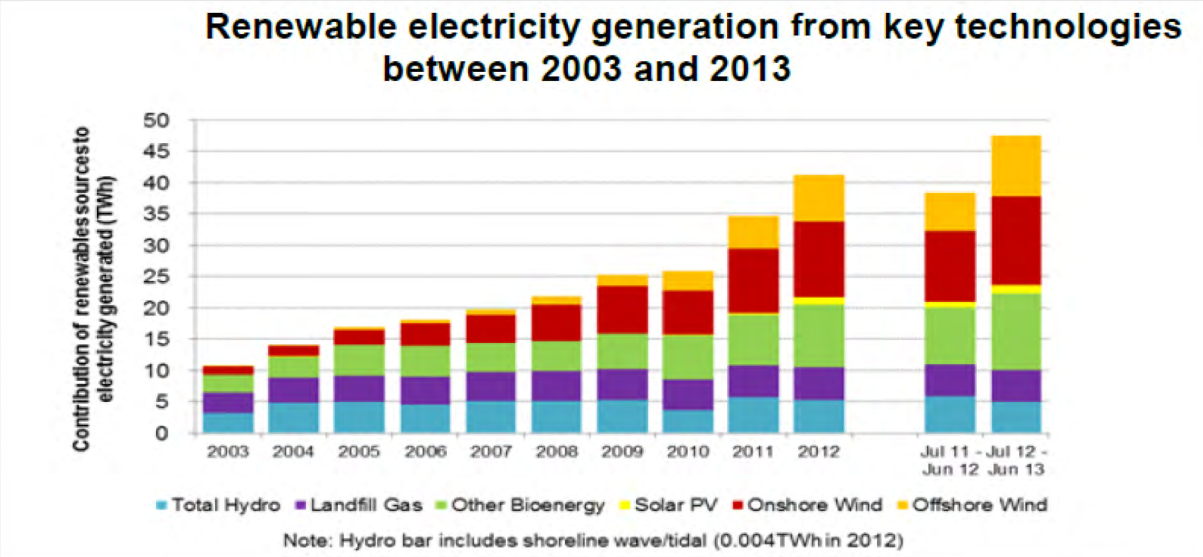


The public also prefers certain renewable to others, so this will have a major bearing on the choice of energy source for locations. Solar energy is 15% more popular than onshore wind energy.

SAMPLE LEARNER WORK



This has resulted in the generation of energy over the past 10 years.



SAMPLE LEARNER WORK

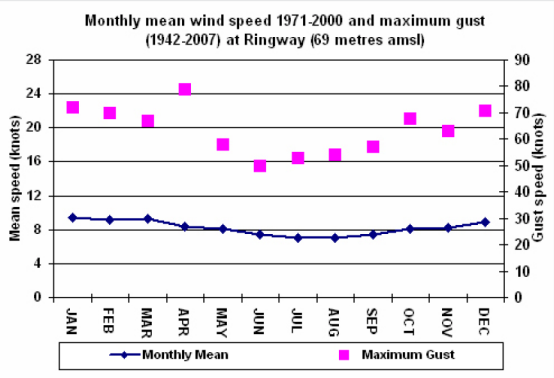
Before a choice can be made planning regulations have to be considered.

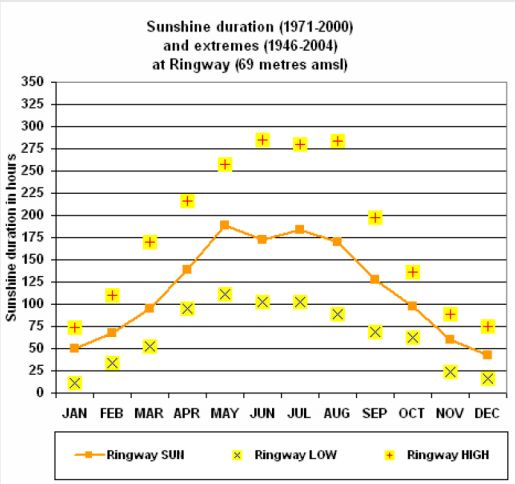
Planning considerations	
Technical details	Energy production for number of homes, instillation area, resources need for generation
Traffic and Transportation	Consider what needs to be brought to the site will it be by: road, rail, canal, river or conveyor
Landscape and Visual Assessment	Consider against what is already in the landscape, would be unduly obtrusive, regarding: size, height , landscaping
Noise and Vibration	Consider noise and vibration levels during stages of: construction, operation
Ecology	A habitat survey is required for signs of protected, rare or notable species within and associated with the site
Air Quality	Consider emissions: gases, dust
Local amenities	Consider the effect of the plant to the public generally. Loss of amenities, employment, house prices, TV reception

The choice will also depend on the geography and climate of the area.

A new town of a population of 20,000 of approximately 9,000 households is to be sited in Lancashire towards the Pennine region.

The climate (based on Met Office records) gives an average wind speed of 10knots and sunshine of 50 to 150 hours per month over the year. The average rainfall is 55mm per month.





The sunshine is restricted by rain and fog. The land tends to be wet and boggy due to the rain.

The area of land is South of the National Park – Lake District and is mainly rural with no local urban area apart from the new town. So there will be little restriction due to planning regulations.

An application by a Wind Power company is to be made to build 6 2.5MW wind turbines requiring an area of 0.6 square mile area. The average wind speed will produce over 18MW of energy over the year sufficient for 10.000 households so giving spare capacity.

The wind turbines are sited 5 km from the nearest farm property so the household will not be affected by noise. No transport issues will arise following the 6 month construction period.
Flight paths of aircraft flying into Manchester and Liverpool area 50 miles away so the 100m high towers will not present any danger.

Task 2 – Nuclear radiation – the benefits, drawbacks and risks

Nuclear ionising radiation has a range of applications; it is not just used for power generation.

Where it helps secure the UK's energy supplies and help the UK meet its decarbonise and meet legal low-carbon obligations but it benefits the economy more widely by producing large quantities of low carbon electricity.
It is also used in smaller power plants, such as in submarines, producing large amounts of power for a small amount of material allowing submarines to submerge months at a time.

There are three types of nuclear ionising radiation: alpha, beta and gamma. They can be categorised as seen below.

Source	Plutonium-239	Strontium-90	Cobalt-60
Ionising Radiation	α- particles	β -particles	γ-ray
Type of particle	Helium nucleus positive particle	Electron negative particle	Electromagnetic wave
Penetrates	Stopped by paper Stopped by 6cm air	Stopped by 3mm aluminium	Slowed by lead
Causing ionisation	Yes Strongly	Yes Weakly	Yes Very Weakly

Alpha is the least penetrating and gamma the most.

These radioactive of a substance will decay away over time
- α- decay
- Radium-226 decays by emitting α- particles (helium nucleus) to form Radon-222
- β - decay
- Polonium-218 decays by emitting β –particles (an electron) to form Astatine-218
- Gamma – emission
- When a α- particle or a β –particle is emitted the nucleus of the atom is in an exited state and loses energy in the form of γ-rays

The half-life of a substance is the time taken for half the number of atoms to decay and that half-life of different substances can be fractions of a second or millions of years.

Based on these properties nuclear ionising radiation is used in:
- Healthcare, especially in radiography; radiotherapy; nuclear medicine; sterilisation.

- Industry, such as quality control of materials; measuring the level in containers; monitoring the thickness or consistency of paper; modification and preparation of polymeric materials and composites; irradiation of foods.

SAMPLE LEARNER WORK

Healthcare

Ionising radiation is used in medicine in 3 ways:

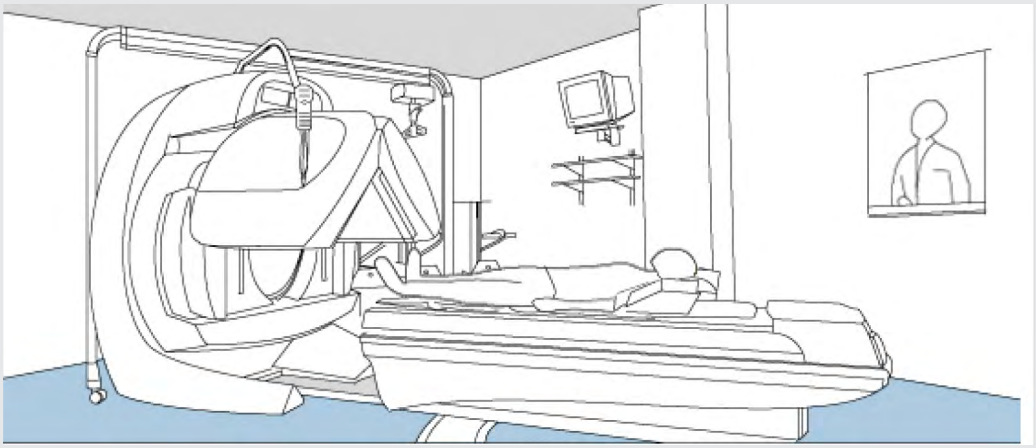
- diagnostic radiology, which uses x-ray machines to obtain images of the inside of the patient's body
- nuclear medicine, which uses radioactive substances introduced into the patient for diagnosis or treatment
- radiotherapy, which uses many types and sources of ionising radiation to cure or relieve symptoms of cancer and other diseases.

These 3 areas are covered by the Ionising Radiation (Medical Exposure) Regulations 2000, which provide a framework to protect patients.

1. Nuclear Medicine

Nuclear medicine is a method of imaging the physiological processes of the body using radioactive tracers. It is a different process from x-rays, CT, MRI and Ultrasound all of which are mostly looking at the anatomy of the body.

To look at the function of the body, Nuclear Medicine uses gamma rays. The major difference is that the gamma rays are emitted by pharmaceuticals injected into the bloodstream rather than being produced by machines outside the body. The gamma rays are detected by this gamma camera that builds up a picture of the area of the body under investigation.



Nuclear medicine is uniquely suited to tissue characterisation, early assessment of the extent and severity of disease, and treatment of disease. It is giving new insights in the understanding of the dementias, the spread of cancer, and the early detection of coronary-artery disease.

Risks of Nuclear medicine
The amount of radiation in the tracer is equivalent to the radiation you are exposed to when you have an X-ray. The benefits of the scan far outweigh any potential risk from the radiation. The tracer will not produce any side effects.

2. Radiotherapy

Radiotherapy is the controlled use of high energy X-rays to treat different types of cancer and benign tumors. Radiotherapy is only used if the benefits outweigh the risks. About 4 out of 10 people with cancer have radiotherapy.

Radiotherapy is used to:
- to cure an illness - by destroying a tumor (abnormal tissue)
- to control symptoms - to relieve pain
- before surgery - to shrink a tumor to make it easier to remove
- after surgery - to destroy small amounts of tumor that may be left

Radiotherapy is sometimes used to treat thyroid disease, as well as some blood disorders and other benign conditions.
The length of each course of radiotherapy will depend on the size and type of cancer and where it is in the body.

Radiotherapy can be given:
- outside the body - using X-rays, external radiotherapy is usually given once a day as a course of treatment over a number of days or weeks
- within the body - either by drinking a liquid that is absorbed by the cancerous cells or by putting radioactive material into, or close to, the tumor, usually for a small number of treatments or by injecting or drinking a liquid that is absorbed by the cancerous cells.

Courses of radiation
Radiation treatment is given in doses which are usually given over a number of weeks. This is done to reduce the side effects of a full dose of radiation. Side effects occur because radiotherapy temporarily damages some of the healthy cells as well as destroying the cancerous ones. Common side effects of radiotherapy include:
- sore skin
- tiredness
- feeling sick
- dry mouth
- loss of appetite
- diarrhoea
- hair loss
- discomfort on swallowing
- a lack of interest in sex
- stiff joints and muscles

Various nuclear isotopes are used in a wide range of applications in medicine.

Some Isotopes used in Medicine	
Isotope	**Use**
Technetium-99	To image the skeleton and heart muscle in particular
Chromium-51	Used to label red blood cells and quantify gastro- intestinal protein loss
Cobalt-60	Used for external beam radiotherapy
Erbium-169	Use for relieving arthritis pain in synovial joints
Iodine-125	Used in cancer of the prostate and brain, also diagnostically to evaluate the filtration rate of kidneys and to diagnose deep vein thrombosis in the leg
Iron-59	Used in studies of iron metabolism in the spleen
Strontium-89	Very effective in reducing the pain of prostate and bone cancer
Cobalt-57	Used as a marker to estimate organ size

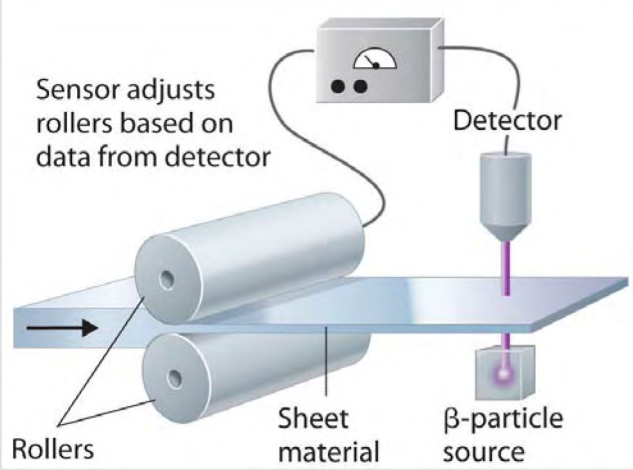
3. Sterilising equipment

Gamma rays are high energy electromagnetic waves which are only stopped by thick lead. This means they can easily pass through medical equipment, such as syringes and packaging.
Sterilization kills the bacteria (or any types of cells), on medical instruments, the radiation damages the cell's chromosomes, specifically the DNA. Radiation has enough energy to ionize atoms and molecules in a cell's nucleus so the cell cannot function properly or reproduce and the result is cell death or sterilization.

Industry

Industrial applications of radiation

1. Quality control of materials - measuring the level of containers, or monitoring the thickness or consistency of paper.



Devices which monitor industrial processes consist of radiation sources and detectors.
When the material between the radioactive source and the detector changes thickness or density, the level of radiation detected also changes.
The process can be controlled by weakening or strengthening the signal from the detector.

2. Industrial radiography is a method of non-destructive testing, used to check for flaws in metal structures and welding seals, among others.

It is the same as in medical X-rays where radiation passes through the object to be tested and exposes the X-ray film placed behind it. Dark patches in the developed film reveal flaws.
Radiography devices create radiation using either X-ray machines, or for thicker material, a gamma source or linear accelerator.
In gamma radiography, the radiation comes from a radioactive source, such as Iridium-192. The radioactive source is placed in a portable protective container during storage and transport. When in use, the source can be pushed forward to the radiating position with the help of a mechanical crank. After use, the source is then returned to its shielded position.

Gamma sources are more portable than x-ray equipment. They will emit a narrower range of wavelengths at greater energy and so can be more focused and giving a more defined image.

Where a weld has been made in an oil or gas pipeline, film is taped over the weld around the outside of the pipe.
A "pipe crawler" carrying a shielded radioactive source crawls down the inside of the pipe to the position of the weld. There the radioactive source is remotely exposed and a radiographic image of the weld is produced on the film. This film is later developed and examined for signs of flaws in the weld.

3. Radioactive tracers are used plants

In agriculture to see how a plant takes up a fertiliser - a solution of phosphate containing radioactive phosphorous (^{32}P) is injected into the root system of a plant.
It will be used by the plant the same way as it uses phosphorus in a normal fertiliser. A GM counter can detect the movement of the radioactive phosphorus throughout the plant.

Nuclear Power Generation

Nuclear power uses the nuclear fission of uranium to create heat and through a heat transfer mechanism and turbines generate electricity.
Uranium fuel pellets are bombarded with neutrons which cause the uranium atoms to split. This nuclear fission creates enormous amounts of heat.

Nuclear power plants are an alternative to coal powered plants as they are more efficient – 250g of uranium produces 20,000 times more electricity than the same amount of coal. It does not emit harmful greenhouse gases.
Nuclear plants are generally a reliable process that can produce electricity for over 40 years with the amount waste material covering a table top.
The process is considered renewable.

However radioactive waste is produced which is harmful and has to be stored under specific conditions.
The major problem is the risk of leaks and accidents.

- 1986 Chernobyl disaster emitting radiation ranging from 800 to 16,000 mSv. This is 40 to 800 times more than allowed for radiation workers.

- Fukushima Daiichi plant, radiation dose levels reached 400 mSv per hour (20 times more than a worker should be exposed to) in one of the reactors.

The Government supports Nuclear Power.

The Secretary of State considers that potential environmental risks arising from the construction, operation and decommissioning of the new Nuclear power stations are likely to be avoided or adequately mitigated. The environmental impacts of new nuclear power stations would be comparable with, or less than, those of other forms of large scale electricity generation.

Over a 60 year lifetime new nuclear power stations could save 1.7 billion tonnes of carbon dioxide (CO2) compared with generating the same energy from gas-fired power stations.

The Secretary of State sees a clear need for the generation of electricity by new Nuclear power stations as they will: secure the UK's energy supplies, help the UK decarbonise and meet legal low-carbon obligations, benefit the economy more widely and produce large quantities of low carbon electricity over an extended period.

SAMPLE LEARNER WORK

The Secretary of State considers that the risk of health from the building and operation of new Nuclear power stations is very low.

- radiation dose which the public would receive would be below detectable risk levels
- safety features in design will keep gaseous and aqueous emissions to a minimum
- risk of accidental release of radioactive will be reduced and mitigated.

The Secretary of State acknowledges the risk from an accident or terrorist incident at nuclear power stations could happen, consequently contingency plans have been drawn up.
The Government has set up a number of guide lines so that the use of nuclear energy is safe.
No practice involving exposure to radiation should be adopted unless it produces sufficient benefit to the exposed individuals or to society to offset the radiation detriment it causes.
This decision is made at government level through the regulatory justification process.
The radiation exposures resulting from the practice must be reduced to the lowest level possible considering the cost of such a reduction in dose.
This involves setting upper limits on the dose that any member of the public should receive from all man-made exposures (other than medical exposures).

These limits are imposed by regulatory agencies such as the Health and Safety Executive based on:

1. Time:

For people exposed to radiation in addition to natural background radiation, limiting or minimizing the exposure time will reduce the dose from the radiation source.

2. Distance:

Radiation intensity decreases sharply with distance, according to an inverse-square law.

3. Shielding:

Air or skin can be sufficient to substantially attenuate low-energy alpha and beta radiation. Barriers of lead, concrete, or water give effective protection from more energetic particles such as gamma rays and neutrons. Some radioactive materials are stored or handled underwater or by remote control in rooms constructed of thick concrete or lined with lead. There are special plastic shields that stop beta particles, and air will stop most alpha particles. The effectiveness of a material in shielding radiation is determined by its half-value thicknesses, the thickness of material that reduces the radiation by half. This value is a function of the material itself and of the type and energy of ionizing radiation. Some generally accepted thicknesses of attenuating material are 5 mm of aluminum for most beta particles, and 3 inches of lead for gamma radiation.

Although many occupations have a risk, these risks are seen as tolerable and acceptable. By comparing these risks the use of nuclear Power can be put into perspective.

SAMPLE LEARNER WORK

The tables below give a comparative risk of death:

Comparison of levels of fatal risk per annum – every day risks
1 in 100 risk of death from five hours of solo rock climbing every weekend
1 in 1000 risk of death due to work in high risk groups within relatively risky industries
1 in 10000 general risk of death in a traffic accident
1 in 100000 risk of death in an accident at work in the very safest parts of industry
1 in 1 million general risk of death in a fire or explosion from gas at home
1 in 10 million risk of death by lightning

Comparison of levels of fatal risk per annum - in industry
1 in 750 risk of death for deep sea fishermen on vessels registered in UK
1 in 990 risk of death in extraction of mineral oil and gas
1 in 3,900 risk of death in extraction of minerals and ores
1 in 7100 risk of death in coal extraction
1 in 10200 risk of death in construction
1 in 13500 risk of death in agriculture
1 in 53000 risk of death in all manufacturing industry
1 in 1 million risk of cancer from a general nuclear plant accident.

These acceptable risks put the risk of nuclear power into perspective.

Level of risk from nuclear energy industry
1 in 10^4 Range of risk to average nuclear power worker 1 in 10^6 Range of risk to members of the public living near nuclear installations from any kind of nuclear accident 1 in 10^7 Range of risk to the average member of the UK public from normal operation plus possible nuclear accidents.

Figures from "Tolerable risk from nuclear power stations" HSE
http://www.hse.gov.uk/nuclear/tolerability.pdf

SAMPLE LEARNER WORK

Task 3 – Measuring the efficiency of a small electrical immersion heater

I will measure the temperature rise of a known volume of water over a period of time.
The volume needs to be contained in a vessel that will:

- allow the water to cover the whole of the immersion heater so all of the heat energy goes into the water from the immersion heater
- hold enough water to allow a measureable temperature increase

The vessel should

- have the smallest surface area as possible to have the least surrounding air to it to reduce heat loss to the environment
- be insulated and have a lid to reduce loss of heat to the environment.

The period of time should:

- allow the immersion heater to get up to its working temperature
- long enough to give a significant water temperature rise
- short enough to reduce the amount of heat being lost to the environment.

Equipment:

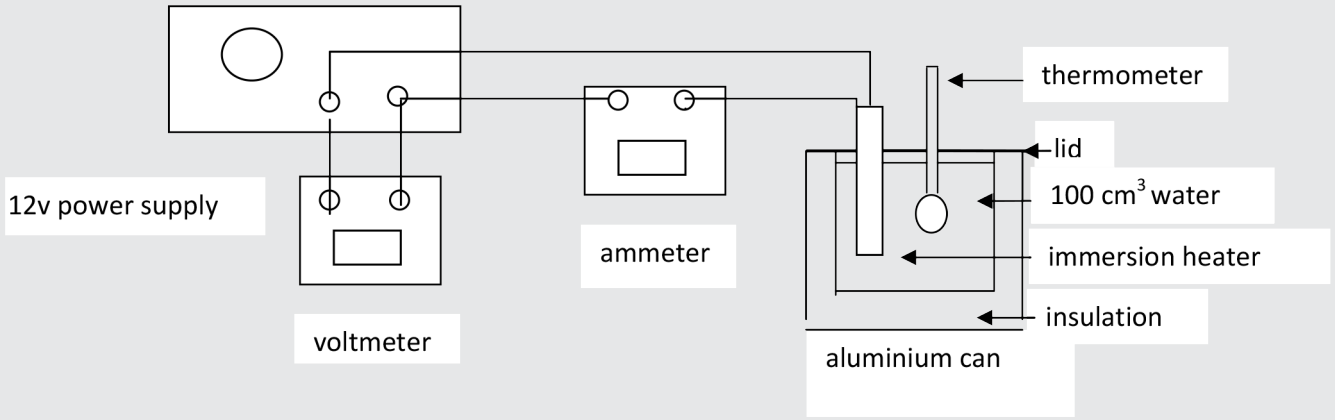
- 12V power supply – a safe working voltage
- ammeter ; voltmeter will measure electrical energy supplied to immersion heater – the instruments will initially be zeroed; be sensitive and be able to measure to 0.01
- 5 x connecting wires – the wire should have the lowest electrical resistance as possible to reduce any electrical energy loss in heat or magnetism; energy loss will also be reduced if the wires are short and thick.
- immersion heater
- thermometer will measure the rise in temperature – the thermometer's calibration can be checked by measuring the temperature of: just melting ice and steam just above boiling water; the precision of reading will depend on the graduations
- aluminium can
- stop-clock will measure the period of time – digital is used to give a faster reaction control.
- 100 cm^3 measuring cylinder will measure the known amount of water.

Procedure:

- With the measuring cylinder, measure water 100cm^3 and pour into the insulated aluminium can
- Check that the power supply is switched off
- Set up the apparatus as shown in the diagram
- Measure the temperature of the water before heating
- Switch on the circuit and measure the electric current and voltage
- After 180s switch off the power supply
- Stir the water and measure final temperature of water
- Repeat the procedure to be able to obtain reliable result.

SAMPLE LEARNER WORK

Apparatus:



Results:

Water (cm^3)	Time (s)	Voltage (v)	Current (A)	Initial temp. (^0C)	Final temp. (^0C)	Temp. Rise (^0C)
100	180	12.08	2.05	21.4	29.8	8.4
100	180	12.08	2.05	21.5	30.1	8.6
100	180	12.08	2.05	21.4	30.0	8.6
Average temperature rise						8.5

Temperature rise is repeatable and the range is within 0.2^0C and 2.4% range.

Calculation 1: Heat energy absorbed by the water over 180s
This is equal to 4.2 x water volume in cm^3 x temperature rise

4.2 x 100 x 8.5 = 3570.0J

Calculation 2: Heat energy supplied by the immersion heater over 180s
This is equal to 300 x ammeter reading x voltmeter reading

180 x 2.05 x 12.08 = 4457.52J

Calculation 3: Percentage efficiency of the immersion heater

This is equal to: $\frac{\text{Heat energy absorbed by the water}}{\text{Heat energy supplied by the immersion heater}} \times 100 = \frac{3570.0 \times 100}{4457.52}$

Efficiency of the heater = 80.1%

Evaluation:

Readings

Temperature rise varied from 8.4 to 8.6 which is a 1.2% variation and was repeated two times, so temperature reading is reliable.
The temperature rise seen in readings 2 and 3 may be due to the heater retaining heat from the previous procedure.
By stirring the temperature reading would be the same temperature throughout the water.
Both voltage and current values were consistent throughout and read to a greater precision of x10 than the final efficiency.

Apparatus

The aluminium can was insulated and had an insulating lid so heat lost to the environment was reduced.

Efficiency was less than 100% because:
Loss of heat to the environment
Electrical energy lost through the wires and meters
Corrosion on the outside of the immersion heater itself.

Further investigation into the immersion heater:
Vary the time to heat up the water to a specific temperature. The heater itself will need time to heat through to its outer casing, this period of time needs to be insignificant to the overall time period of the investigation.
This will find the optimum time that the investigation should be undertaken – optimum time will be when heater heats the water through but not losing significant heat to the environment.

Vary the amount of water; immersion heaters will be limited by their size as to the amount of water it can heat to give a significant raise in temperature.

Competency	MB1	MB2	MB3
Taking measurements			
Some support needed to choose correct equipment			
Choose correct equipment			
Independent selection of equipment/equipment set up correctly			✓
Zero or calibrate apparatus		✓	
Some data recorded			
Record result			
Recorded data to correct significant figures			✓
Appropriate accuracy and precision using an appropriate format			✓
Correctly position eye when taking measurement		✓	
Repeat reliable readings			✓
Maintaining a safe and uncluttered working environment			
Most of the time			
All of the time			
Rigorously and with prior thought and planning			✓
With support carries out risk assessment			
Carries out risk assessment			
Independently carries out risk assessment			✓
Following standard procedures			
With support follows basic standard procedures correctly			
Follows basic standard procedure correctly			
Follows complex procedure correctly			✓
Makes own adaptations to standard procedure to improve reliability			
Assessors signature: XXXXXXXXX Assessors name: XXXXXXXXXX Date:XXXXXXXX			

SAMPLE LEARNER WORK

Task 4 – Case study: Designing a health education programme

Company Challenge

Run a Half Marathon

for Breast Cancer

The comapny will support your training and sponsor you to run in the charity race.

All you have to do is train and run

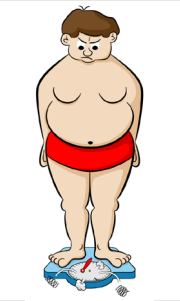
The company has recently reviewed its days off for sickness and have calculated that the company is losing a significant sum of money due to the loss in productivity due to sickness.
It has concluded that investing in a get fit campaign that brings down sickness will in fact make money.
By promoting a sponsored half marathon for charity it will give workers an incentive to get fit and so reduce sickness and also give the company a "good image" which will in turn help sell and so increase profits.

The company will produce not only an exercise programme but also a diet programme as well as information on factors that will affect general health.

SAMPLE LEARNER WORK

Think about your health

Health risks of being Overweight



Measure round your waist

Men are you 94cm or more
Women are you 80cm or more

If you are you need to lose weight

Being overweight affects your health it can lead to diabetes, high blood pressure, coronary heart disease, osteoarthritis and stroke. It can increase the risk of cancer of the bowel, kidney, oesophagus and womb, as well as breast cancer in women who have been through the menopause. More than 41,000 people were diagnosed with bowel cancer in 2009 in the UK, that's more than 110 people every day whereas a diet rich in fibre will reduce your risk.

Helpful hints to lose weight

1. Choose reduced fat versions of foods
2. Walk 10,000 steps each day
3. For a snack, choose fresh fruit or low calorie yogurts
4. Check the food label for the fat and sugar content
5. Keep portions small
6. Think twice before having second helpings
7. Stand up for ten minutes out of every hour
8. Choose water or sugar-free squashes
9. Slow down while eating
10. Don't forget your 5 a day

The eatwell plate for a balanced diet.

SAMPLE LEARNER WORK

Health risks of smoking

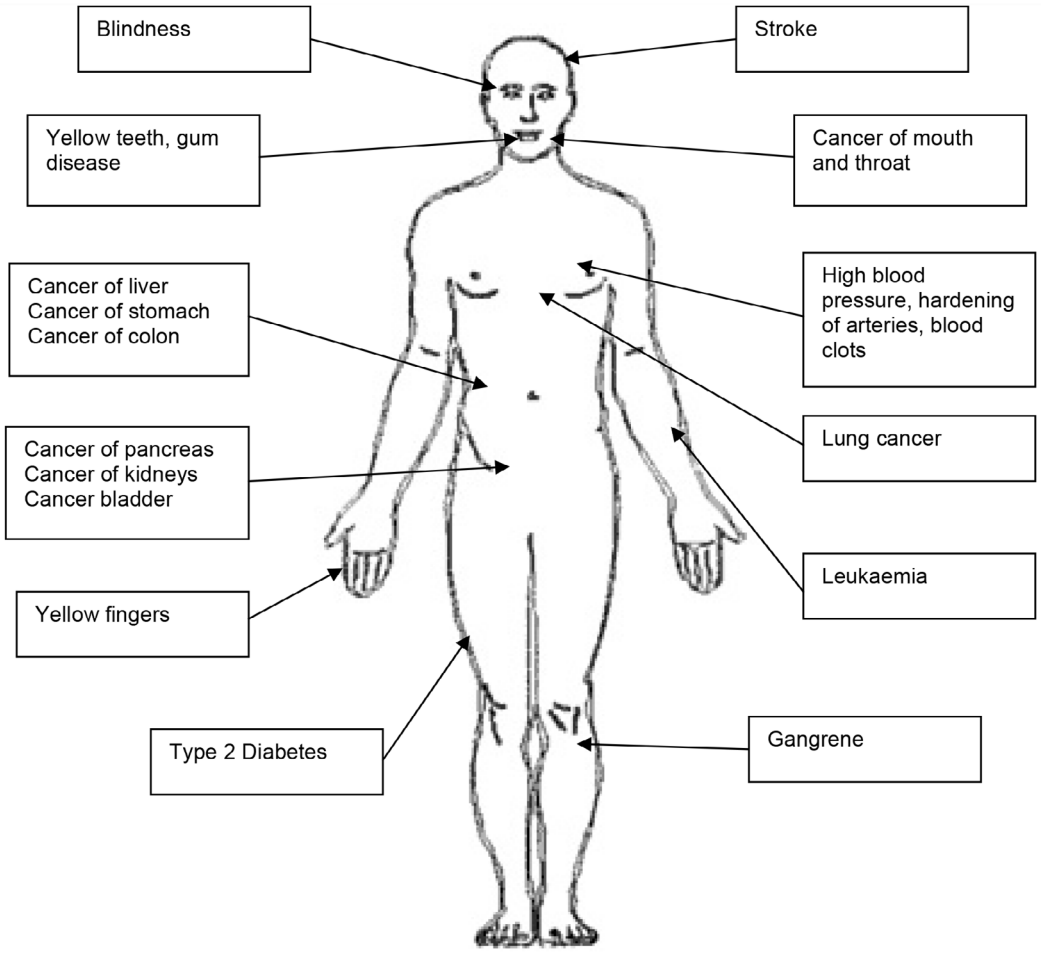
About 100,000 people in the UK die each year due to smoking.

Smoking-related deaths are mainly due to cancers, chronic obstructive pulmonary disease (COPD) and heart disease.
2,000 a year get gangrene and lose a leg

If you are a long-term smoker, on average, your life expectancy is about 10 years less than a non-smoker.

Smokers' cough

You smell

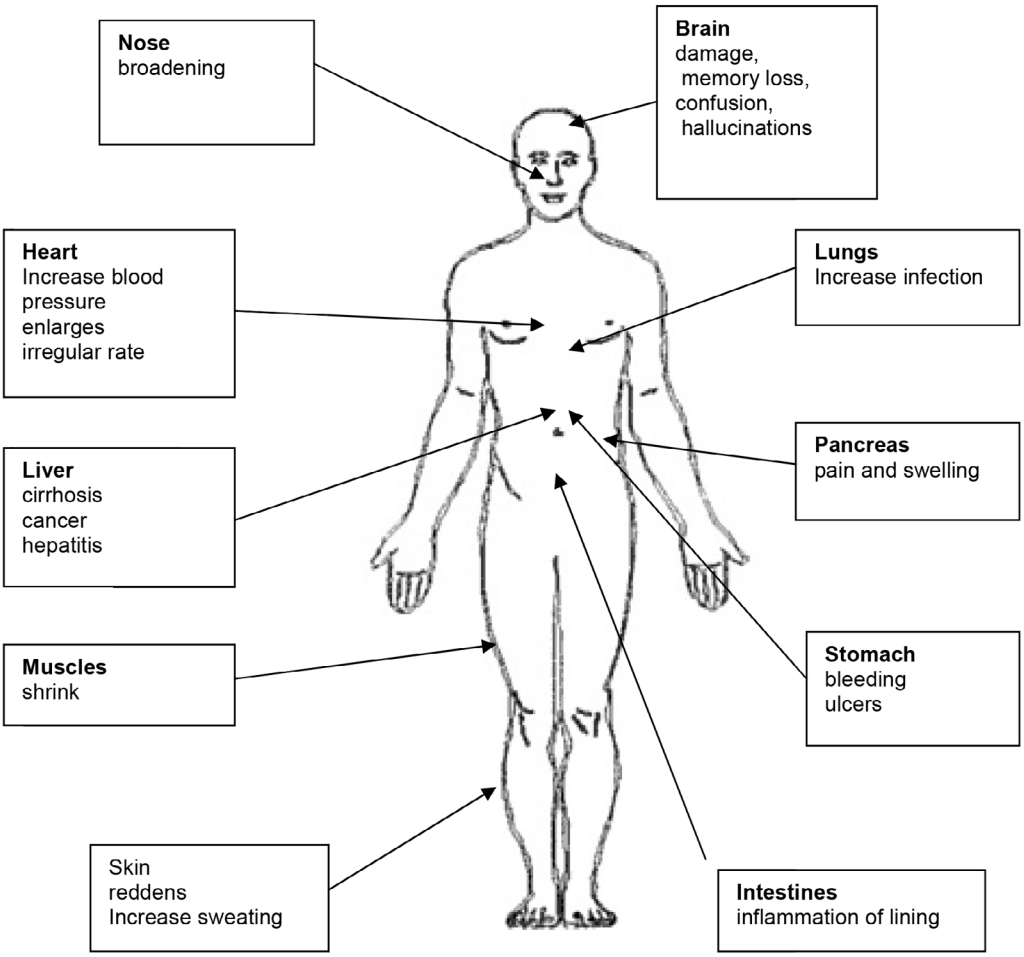


Carry on smoking and you could have all of this

SAMPLE LEARNER WORK

Health risks of drinking alcohol

Each year 5,000 to 10,000 people die prematurely from alcohol.
It is a depressant – slows down body's reactions, larger amounts can make one dizzy and impairs judgments
Leads to lose of control – of muscles and speech and one become less co-ordinated and can even pass out
Leads to aggression – in some people it can cause aggression leading to fights.



If you want all of these, just keep on drinking

SAMPLE LEARNER WORK

Health risk of drug taking

There were 2,652 drug-related deaths registered in England and Wales in 2011.



Injection drug use is a well-known route of transmission of blood borne infections, particularly HIV and hepatitis B and C. Use of illicit drugs is associated with increased rates of TB and STDs.

Stimulants can cause - Increased heart rate, blood pressure, body temperature, metabolism as well as tremors; reduced appetite; irritability; anxiety; panic; paranoia; violent behavior; psychosis
Also weight loss, insomnia; cardiac or cardiovascular complications; stroke; seizures; addiction

Hallucinogens can cause - altered states of perception and feeling; hallucinations; nausea. Can also increase body temperature, heart rate, blood pressure; loss of appetite; sweating; sleeplessness; numbness, dizziness, weakness, tremors; impulsive behavior; rapid shifts in emotion

Depressants can cause - drowsiness, lowered inhibitions, slurred speech, poor concentration, confusion, dizziness, impaired coordination and memory. Also health consequences - lowered blood pressure, slowed breathing, tolerance, withdrawal, addiction; increased risk of respiratory distress and death when combined with alcohol

Just say NO to drugs

SAMPLE LEARNER WORK

First off – how fit are you, let's find out.

Step Test. This test will give you some idea of your cardiovascular strength.

All you need is steps about 12 inches high and a watch or stopwatch.
Step up onto the stair with both feet and then step down very briskly for 3 minutes, do keep to a fairly brisk rate.
At the end of 3 minutes check your pulse rate.

Men

Age	Excellent	Good	Above average	Average	Below average	Poor
18-25	79	79-89	90-99	100-105	106-116	117-128
26-35	81	81-89	90-99	100-107	108-117	118-128
36-45	83	83-96	97-103	104-112	113-119	120-130
46-55	86	86-97	98-103	104-112	113-120	121-129
55+	87	87-96	97-103	104-113	114-120	121-130

Women

Age	Excellent	Good	Above average	Average	Below average	Poor
18-25	85	85-98	99-108	109-117	118-126	127-140
26-35	88	88-98	99-108	109-119	120-126	127-140
36-45	90	90-102	103-110	110-118	119-128	129-140
46-55	94	94-104	104-115	116-120	121-129	130-141
55+	95	95-104	105-117	118-122	123-131	132-142

Resting Heart Rate. Routinely taking your resting pulse rate each morning it is a good indication of fitness.

Use the radial artery on your wrist and press lightly with two fingers. Find the pulse, count the beats for 30 seconds and multiply by 2 for the heart rate per minute.

Men

Age	20-29	30-39	40-49	50+
Excellent	59 or less	63	65	67
Good	60-69	64-71	66-73	68-75
Fair	70-85	72-85	74-89	76-89
Poor	86+	86+	90+	90+

Women

Age	20-29	30-39	40-49	50+
Excellent	71 or less	71 or less	73 or less	75 or less
Good	72-77	72-79	74-79	76-83
Fair	78-95	80-97	80-98	84-102
Poor	96+	98+	99+	103+

SAMPLE LEARNER WORK

Flexibility. You should stretch before and after training sessions.

Tight ham strings and back muscles will cause problems later on and could lead to injury.

Flexibility Test

Warm up before the test and stretch.
You need a box, a marker pen and a tape measure.
Sit on the floor with feet resting against the box. Slowly reach forward to the box and mark how far across the box you can reach. Complete three times and take the average score in centimetres.

Men

Excellent	Above average	Average	Below average	Poor
Above 7cm	3cm to 7cm	-2cm to 2cm	-6cm to -3cm	Below -6cm

Women

Excellent	Above average	Average	Below average	Poor
Above 9cm	9cm to 4cm	3cm to 0cm	-1cm to -5cm	Below -5cm

Next – Diet eat a proper balanced diet but you will need to be prepared for running

To give you enough energy for training have six servings of grains, beans or starchy vegetables a day.

Also every day have 3-5 servings of vegetables and 2-4 servings of fruit.

Have 2-3 servings of protein, fish, meat, cheeses, nuts, tofu or eggs per day.
You need protein to repair damaged tissue and build muscle.

Only eat fats in small quantities such as olive oil dressing or spread or a small handful of nuts as a snack, both these foods are monounsaturated fats. You should also drink skimmed or semi-skimmed milk or eat low fat yoghurt. Avoid saturated fat found in cream or red meat as they clog arteries, increase blood pressure and can lead to heart problems.

After a run to replace the glycogen you have used, eat about 250g of carbohydrates, such as an energy bar or a banana and have a drink of water.
An hour after running you need to eat something more substantial; 50-100g of carbohydrate and protein like a tuna or chicken sandwich or pasta, plus more fluids.

The two keys to a healthy diet are:
- Eat the right number of calories
- Eat a balanced diet.

The average man needs around 2,500 calories a day. The average woman needs 2,000 calories. Most adults are eating more calories than they need, and should eat fewer calories.

SAMPLE LEARNER WORK

People should eat enough food to give them energy for their age, it is recommended that the amount of calories consumed is:

Age	Male		Female	
	(MJ)	(kcal)	(MJ)	(kcal)
0-3 months	2.28	545	2.16	515
4-6 months	2.89	690	2.69	645
7-9 months	3.44	825	3.20	765
10-12 months	3.85	920	3.61	865
1-3 years	5.15	1230	4.86	1165
4-6 years	7.16	1715	6.46	1545
7-10 years	8.24	1970	7.28	1740
11-14 years	9.27	2220	7.72	1845
15-18 years	11.51	2755	8.83	2110
19-50 years	10.60	2550	8.10	1940
51-59 years	10.60	2550	8.00	1900
60-64 years	9.93	2380	7.99	1900
65-74 years	9.71	2330	7.96	1900
74+ years	8.77	2100	7.61	1810

Certain foods will contain different amounts of calories e.g.

Food	kJ	kcal
Breakfast		
Cornflakes (30g)	1590	380
Muesli (30g)	1790	425
Porridge (30g)	190	45
Egg, boiled (55g)	610	145
Egg, poached (55g)	645	155
Bacon, fried (40g)	1975	475
Bread, brown (25g)	1015	240
Snack		
Biscuit chocolate (20g)	2200	525
Biscuit ginger nut (15g)	1925	455
Cake fruit (60g)	1490	355
Coffee (230g)	8	2
Tea (230g)	2	1
Dinner		
Pork, roast (120g)	1190	285
Potato, boiled (120g)	345	80
Peas (60g)	225	50
Custard (70g)	495	120
Sponge pudding (100g)	1445	345

So count your calories!

Learning Objective 1 - Be able to analyse personal and social choices related to energy supply

Marking commentary on MB3 sample learner work

A detailed description of energy sources is given with their advantages and disadvantages using technical quantitative data with appropriate formats to analyse energy efficiency of generation; charts were used to give a comparison of costs, efficiencies of generation and peoples' preference for the different energy sources. Distribution efficiency across the grid was also explained.
Relevant factors that the contractor considers were listed to meet planning regulations – greater detail, showing comprehensive understanding, was given in the presentation which was "tied" to a specific proposal.
The learner's evidence was put into a real context and had the necessary vocational approach to give the learner a "real world" experience.
The detail and understanding puts the task outcome at the upper range of MB3.

Why it was awarded MB3 not MB2

The number of energy sources is at the upper range expected at MB3, for MB2 six sources would have sufficed.

The detailed description includes a wide range of quantitative data at MB2 quantitative data is not necessary but here the detail allows technical choice of source to be made. Each of the sources has shown comprehensive understanding of the relevant factors so a sound choice can be made, whereas at MB2 only some are expected.

Four efficiencies have been compared, for MB2 only two would be needed however the level of complex quantitative analysis is at an MB2 level however detailed information from Government data supporting social choice has been used to support choice which you would not expect at MB2.

When making a choice planning regulation, the geography and climate of the location have been considered, backed by a quantitative technical choice which is expected at MB3.

Learning Objective 2 - Understand the risks and benefits related to the applications of nuclear radiation

Marking commentary on MB3 sample learner work

The learner has referred to regulations governing radiation and realizes that the use of radiation is subject to risk assessment and control measures – a basic concept running throughout all aspects of science.
Reference is made to the effect of radiation on organisms and the relative exposures at Chernobyl and Fukushima (reference to the illness caused to the local population might have been made to underline the concern of the use of radiation).
The learner has linked their evidence to the Government's view on nuclear power and has listed a quantitative analysis of the uses of radiation to the individual/wider society of risk. They refer to the tolerance of acceptable risk showing that the learner has an awareness of present day politics and that decisions may not be wholly based on science alone.
There is detailed information on a range of applications (4 healthcare; 4 industrial) giving both benefits and risks. Reference is made to how risks are used – dosage, protection but the learner could have given more detail for the industrial applications referring to penetration of the radiation used in the application.
There is a wide range of applications with detailed analysis but with quantitative evaluation. Overall task outcome middle/lower MB3.

Why it was awarded MB3 not MB2

For MB3 healthcare, industry and power applications are included with 3 to 4 uses for each. For MB2 only 2 applications are required with 3 to 4 uses for the two.
X-rays have not been used as an application as they are not produced by nuclear ionising radiation.

A wide range of relevant Isotopes have been included when analysing the applications giving greater detail of the characteristics of radiation at MB2 only two to four named isotopes would be expected alongside the type of radiation.

Quantitative evaluation of risk based on Government data has been included, at MB2 qualitative statements are expected.
Justification for reducing risk based on Government information is included but at MB2 simple qualitative statements are expected.

Learning Objective 3 - Be able to measure energy transfers and calculate efficiencies

Marking commentary on MB3 sample learner work

Witness statement supports that the equipment was independently selected and set up and calculations independently and correctly used with appropriate equations.
Measurements have been repeated with them being within a consistent range.
Measurements are recorded with accuracy and precision stating error.
There is an understanding of the energy transfers and loss of energy and how improvements to the procedure could be made.
Supported by a witness statement with competences in MB3.

Why it was awarded MB3 not MB2

Independence has been shown both in selecting and setting up the equipment, if help is required setting up the equipment then it is at MB2 level. All the measurements are recorded indicating the same accuracy and precision has been used which is shown by the values' significant figures and all have the correct unit; at MB2 measurements need only to be recorded using the appropriate format.

Independence is indicated in both using the correct equations and manipulating them whereas at MB2 support could be supplied. All calculations are correct whereas at MB2 only one outcome needs to be derived correctly.

Learning Objective 4 - Understand how human health can be improved

Marking commentary on MB3 sample learner work

Relevant material was produced supported by "eye catching" images; the learner has a "reduced" amount of text on the leaflets so to be easily assimilated.
Awareness information of the impact on health of certain environmental factors was listed with both qualitative and quantitative data.
Although the information was "listed" overall it produced a detailed explanation that graphically informed the staff.
A diet/fitness plan specific for a half marathon was produced that could be followed; the fitness part was in detail but the diet could have had greater detail with reference to calories quantities and actual food to be eaten.
Overall the outcome of task met the perimeters set out by the learner and was within MB3.

Why it was awarded MB3 not MB2

For MB3 a series of leaflets giving a more in depth explanation of 4 factors which affect health; whereas for MB2 only 3 factors are expected.

For MB3 quantitative data needs to be specific to the client group chosen for the health programme however at MB2 general quantitative data can be given as information.
Get fit information for MB3 could include self-assessment as well as a designated exercise programme and for MB3 Body Mass Index has been referenced.

Learning Objective 5 - Understand the risks and benefits of medical treatments

Marking commentary on MB3 sample learner work

Information produced covers the treatment for a cornea transplant with a quantitative statement. Written for a patient with qualitative statements from secondary sources to support the treatment.
The necessary information was covered for clinical trials at a basic level within MB3. The research/study of the learner was at the higher level but the evidence produced could be more focused on the patient's needs, consequently the outcome is bottom of MB3.

Why it was awarded MB3 not MB2

The benefits and risks of a treatment for all MBs only 1 treatment is needed for MB3 quantitative data on risk and benefit is included whereas for MB2 only a qualitative analysis needs to be made. At MB3 the information is focused at the patient and the material is designed for a patient so it is concise rather than a general discussion of the treatment.

How a new treatment is tested at MB2 needs to included: laboratory testing, animal testing, blind testing but at MB3: in vitro testing; in vivo testing; phase I,II and III testing needs to be included.

Learning Objective 6 - Be able to measure the environmental effects of human activity

Marking commentary on MB3 sample learner work

A witness statement records that the learner independently selected and set up their equipment. Understanding was shown for why measurements needed to be taken and the range of data required. Relevant data was collected with an understanding of accuracy while reliability was displayed appropriately using tables and a chart. The diversity index was calculated for the location.
The learner gave a detailed analysis and evaluation of the findings.
Outcome towards upper MB3.

Why it was awarded MB3 not MB2

A range of data both for MB2 and MB3 includes physical data of the location, such as weather, climate (depending on survey itself:- human activity, air flow or water flow), Biotic and abiotic data, including:

- depending on survey: indicating vegetation count, vertebrate count or invertebrate count
- pH
- chemical tests (such as for sulphates, chlorides, carbonates)
- particulates.

For MB2 the biotic & abiotic information should include at least 1 set of data from each with a simple calculation such as frequency; however at MB3 biotic & abiotic information must include at least 1 set of data from one and 2 sets from the other with a complex calculation such as biodiversity.
There is an accurate visualization of data linked to the sample sites, for MB2 only some relevant visualization is required.

Learning Objective 7 - Understand how materials we use are made from natural resources

Marking commentary on MB3 sample learner work

The teacher on the record sheet stated there was an independent selection of a range of different types of materials linked to different parts of a house chosen for their properties.
Knowledge of chemical processes, support by images, including correct and appropriate use of balanced symbol equations and chemical nomenclature with an analysis yields was displayed.
Analysis of impact on the environment of production supported by charts with some alternative production methods were made for lowering environmental impact.
Overall the evidence was well organized and presented; displaying a good understanding of the chemistry involved.
Outcome of task well within MB3.

Why it was awarded MB3 not MB2

Nine types of material linked directly to a house and why they have been chosen based on their properties have been identified independently whereas for MB2 five to seven with some support are identified that are directly linked to the house.

At least two manufacturing processes including correct balanced symbol equations have been given from which two theoretical yields have been calculated. At MB2 only one manufacturing process is given with a theoretical yield calculated. For all the processes rather than some (for MB2) an evaluation of alternative production methods to reduce the impact on the environment has been given.

Learning Objective 8 - Understand how the properties of materials we use are determined by structure and bonding

Marking commentary on MB3 sample learner work

The task used was that of materials in a trainer – it met the necessary assessment criteria.
The teacher on the record sheet stated there was an independent selection of an appropriate range of different types of materials used in a trainer was made.
Thorough understanding of the reasons why these materials are used, clearly related to their properties.
An explanation of how the properties of these materials depend upon structure and bonding was given supported by images.
Outcome of task within MB3 if more quantitative data had been given then it would have moved the mark upwards.

Why it was awarded MB3 not MB2

A range of solid materials used in manufacturing a complex product for MB2 a range of 3/4 materials is expected but for MB3 a range of 5+ materials that are appropriate to the product and this is done without any support at MB3.
General quantitative data can be given for MB2 but the quantitative data must be linked to the material that is being explained for MB3.
The explanation is of greater detail of how properties of materials depend on their structure when applied to their use in the product for MB3.

Learning Objective 9 - Be able to measure the properties of materials to recommend appropriate uses

Marking commentary on MB3 sample learner work

Independent selection of equipment to take measurements; equipment setup correctly for practical testing (6 tests) was supported by the teachers record sheet.
Measurements taken and recorded to appropriate accuracy and precision using an appropriate format, including use of correct units; although only one test had repeat results.
Data processed accurately using appropriate mathematical techniques (calculation of density and stopping force per area) other data was by direct measurement.
The data was tabulated and charted to show comparison of the three trainers.
Although the practical investigations were simplistic they are similar to those carried out by shoe manufactures, however the learner was confined to a shorter testing period than a manufacturer.
Conclusions and evaluations are valid and well set out.
It would be expected that tests would have been repeated to show reliability of results the task outcome can be placed in MB3.

Why it was awarded MB3 not MB2

For all MBs at least 2 materials tested for at least 2 properties. Three materials are tested using seven tests so the range for MB3 is fully met.
Independence has been shown both in selecting and setting up the equipment, if help is required setting up the equipment then it is at MB2 level. All the measurements are recorded indicating the same accuracy and precision has been used which is shown by the values' significant figures and all have the correct unit; at MB2 measurements need only to be recorded using the appropriate format.

Independence is indicated when processing the data using the correct equations and manipulating them and plotting graphs whereas at MB2 support could be supplied. The level of the mathematical technique used in calculating the stopping force of the sole per centimetre squared is a complex technique whereas just calculating means and calculating density would be at MB2.

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