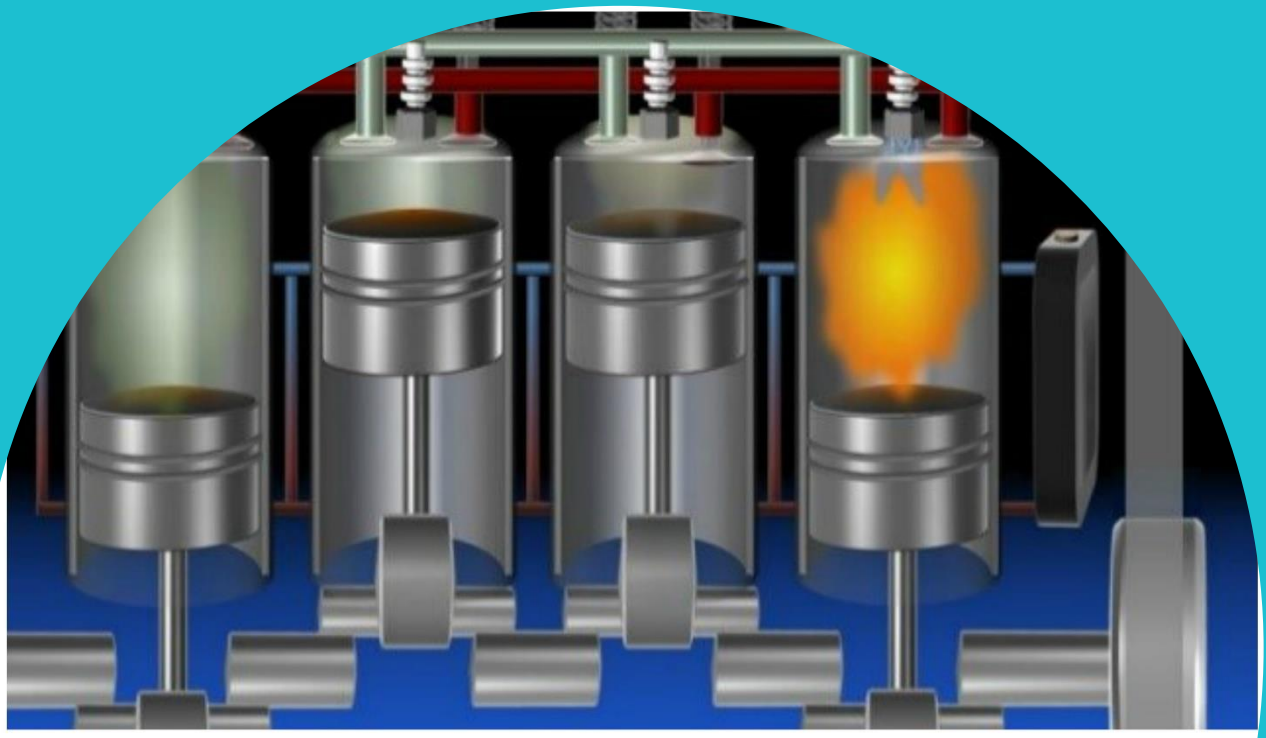

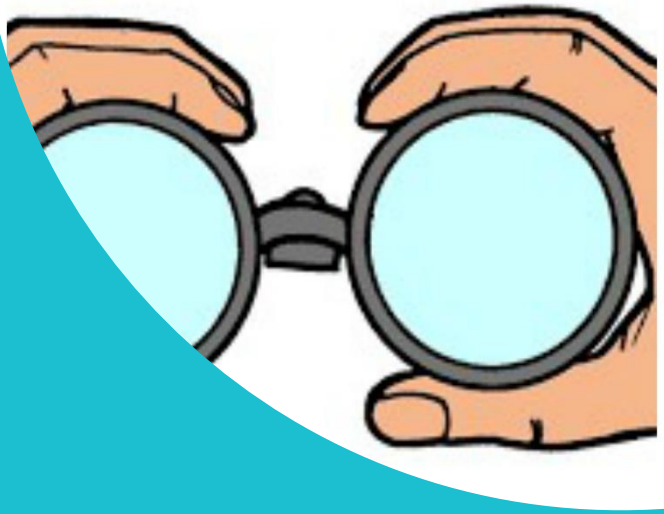

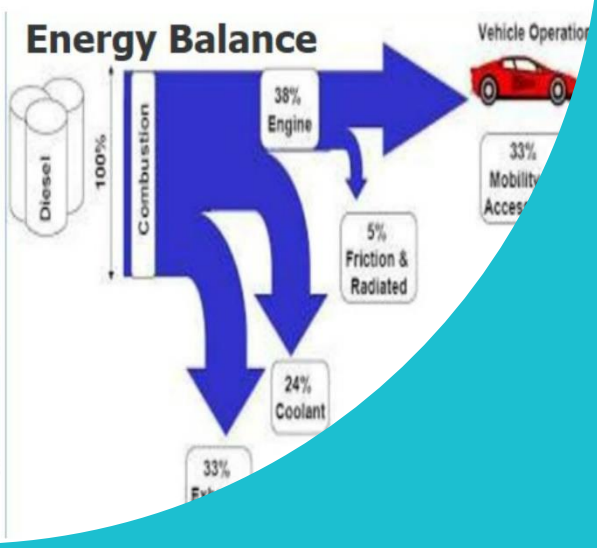


# The energy binocular that can save the world

## Key Stage 4 Programme

| | |
|---|---|
| Pupil Name | |
| Handbook Designed by | Dr. Edirin Agbro |

# Timetable and Assignment Submission

## Timetable – Tutorials

| Tutorial | Date | Time | Location |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 (Feedback) | | | |

## Timetable – Homework Assignments

| Homework Assignment | Description | Due Date |
|---|---|---|
| Tutorial 1 | | |
| Tutorial 2 | | |
| Tutorial 3 | | |
| Tutorial 4 | | |
| Tutorial 5 | | |

## Assignment Submission – Lateness and Plagiarism

| Lateness | |
|---|---|
| Submission after midnight on 9th August | 10 marks deducted |
| **Plagiarism** | |
| Some plagiarism | 10 marks deducted |
| Moderate plagiarism | 20 marks deducted |
| Extreme plagiarism | Automatic fail |

# The Brilliant Club KS5 Programme – Pupil Feedback Report

| Grade | Marks | What this means |
|---|---|---|
| 1st | 70+ | Performing to an excellent standard at A-level |
| 2:1 | 60-69 | Performing to a good standard at AS-level |
| 2:2 | 50-59 | Performing to an excellent standard at GCSE |
| 3rd | 40-49 | Performing to a good standard at GCSE |
| Working towards a pass | 0-39 | Performing below a good standard at GCSE |
| Did not submit | DNS | No assignment received by The Brilliant Club |

| Lateness | |
|---|---|
| Any lateness | 10 marks deducted |
| **Plagiarism** | |
| Some plagiarism | 10 marks deducted |
| Moderate plagiarism | 20 marks deducted |
| Extreme plagiarism | Automatic fail |

| | | | |
|---|---|---|---|
| Name of PhD Tutor | | | |
| Title of Assignment | | | |
| Name of Pupil | | | |
| Name of School | | | |
| ORIGINAL MARK / 100 | | FINAL MARK / 100 | |
| DEDUCTED MARKS | | FINAL GRADE | |

If marks have been deducted (e.g. late submission, plagiarism) the PhD tutor should give an explanation in this section:

| Learning Feedback Comment 1 - *Enter Key Learning Priority Here* | |
|---|---|
| What you did in relation to this Key Learning Priority<br><br>*Enter feedback here* | How you could improve in the future<br><br>*Enter feedback here* |
| **Learning Feedback Comment 2 – *Enter Key Learning Priority Here*** | |
| What you did in relation to this Key Learning Priority<br><br>*Enter feedback here* | How you could improve in the future<br><br>*Enter feedback here* |
| **Learning Feedback Comment 3 – *Enter Key Learning Priority Here*** | |
| What you did in relation to this Key Learning Priority<br><br>*Enter feedback here* | How you could improve in the future<br><br>*Enter feedback here* |
| Resilience Comment | |
| How you showed learning resilience during the course<br><br>*Enter feedback here* | How you could build learning resilience in the future<br><br>*Enter feedback here* |

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# Course Rationale

When we burn petrol and diesel fuels in an engine, the chemical energy stored in the fuel is released to power the engine and move the car but at the same time, part of that energy is lost to the atmosphere as heat through the engine walls and cooling systems or as heat through the exhaust gases. Apart from the fact that we spend more money when our car engines burn fuels inefficiently, the burning of fuels (also known as combustion), also releases various harmful gases through the exhaust which pollute and damage our environment meaning that the more fuel we burn, the more our world is in trouble. It is therefore important that we reduce the amount of fuel energy that is lost when we burn fuels in engines thus explaining the growing need for the development of more energy efficient engines.

How do we know how much of the energy we get from burning fuels in an engine is actually used to drive our car? How do we know where in the engine is most of the fuel energy is lost to the environment so we can make plans to reduce the big energy losses? The answer lies in carrying out an energy balance or heat balance of the engine. An energy balance helps us to see all of the energy flowing into and out of an engine, giving us the opportunity to see where most of the fuel power going into the engine is lost. The energy balance technique is based on the first law of thermodynamics (energy conservation principle) and the result is usually presented using an energy balance sheet (table) and through the use of a Sankey diagram.

Tutorial 1 will introduce the concept of combustion, its various applications and terminologies as well as the basic chemistry (chemical equations) of combustion. Pupils will then be made to understand the process of combustion in internal combustion engines (gasoline engine and diesel engine) and how they work to generate useful energy. Pupils will be finally introduced to how an energy balance is generally performed on a combustion device for improvement of its energy efficiency with specific focus on the gasoline engine in tutorial 4. The final assignment would require the student to analysis the energy balance of a gasoline internal combustion engine via a Sankey diagram which is used for visualising the energy flow in a combustion device. They would also be made to read through a research article exploring the ways to recover energy from a gasoline engine and reduce emissions from the engine. They would be made to review and summarise the article with a focus to developing their research and written communication skills.

# Mark Scheme Table

| | Skills | 1st (70-100) | 2:1 (60-69) | 2:2 (50-59) |
|---|---|---|---|---|
| Subject knowledge | Knowledge and Understanding | ○ All content included is relevant to the general topic and to the specific question/title<br>○ Good understanding of all the relevant topics.<br>○ Scientific terms are defined and used accurately throughout<br>○ Clear justification on how the content included is related to the specific issues that are the focus of the assignment | ○ Most of the content included is relevant to the general topic and to the specific question/title<br>○ Good understanding of most the relevant topics<br>○ Scientific terms are used accurately but not always clearly defined.<br>○ Adequate justification on how the content included is related to the specific issues that are the focus of the assignment | ○ Some of the content included is relevant to the general topic and to the specific question/title<br>○ Good understanding on some of the relevant topics but occasional confusion on others.<br>○ Scientific terms are used mostly accurately with occasional confusion and often not defined.<br>○ Some justification on how the content included is related to the specific issues that are the focus of the assignment |

| | | | | |
|---|---|---|---|---|
| Critical thinking | Research and Evidence | ○ Inclusion of rich sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas<br>○ Use evidence/calculations to support claims/assertions/ideas, consistently clearly and convincingly<br>○ Evidence of further reading beyond materials provided which were used in an appropriate context<br>○ Data is effectively analysed and appropriate assumptions/conclusions are reached | ○ Inclusion of adequate sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas<br>○ Use evidence/calculations to support claims/assertions/ideas, mostly clearly and convincingly<br>○ Evidence of further reading beyond materials provided<br>○ Data is analysed and the assumptions/conclusions that are reached are mostly appropriate | ○ Inclusion of some sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas<br>○ Use evidence/calculations to support claims/assertions/ideas, at times clearly and convincingly<br>○ Limited evidence of further reading beyond materials provided<br>○ There is an attempt to analyse data is and draw assumptions/conclusions |
| | Critical Evaluation | ○ Moved beyond description to an assessment of the value or significance of what is described<br>○ Evaluative points are consistently explicit/systematic/reasoned/justified<br>○ Effective critiques on the reliability of sources provided | ○ Mostly description but some assessment of the value or significance of what is described<br>○ Evaluative points are mostly explicit/systematic/reasoned/justified<br>○ Some evidence of critiques on the reliability of sources provided | ○ Only description with minimal assessment of the value or significance of what is described<br>○ Evaluative points are at times explicit/systematic/reasoned/justified<br>○ Limited evidence of critiques on the reliability of sources provided |
| Written communication | Structure and Presentation | ○ Ideas are presented in paragraphs and arranged in a logical structure that is appropriate for the assignment<br>○ The introduction | ○ Ideas are presented in paragraphs and arranged in a structure that is mostly appropriate for the assignment<br>○ The introduction | ○ Ideas are presented in paragraphs and arranged in a structure<br>○ The introduction mentions how the essay/report will deal with the |

| | | | | |
|---|---|---|---|---|
| | | clearly outlines how the essay/report will deal with the issues<br>○ The conclusion summarises all the main points clearly and concisely<br>○ All calculations, formulas and methods are clearly structured, clear to follow and correct<br>○ Tables and graphs are effectively constructed including appropriate headings, units and scales.<br>○ All sources are referenced correctly in an agreed format | adequately describes how the essay/report will deal with the issues<br>○ The conclusion summarises most of the main points clearly<br>○ Calculations, formulas and methods are mostly structured, clear to follow and correct<br>○ Most tables and graphs are well constructed<br>○ Most sources are referenced correctly in an agreed format | issues<br>○ The conclusion summarises some of the main points clearly<br>○ Calculations, formulas and methods are not always structured, clear to follow and correct.<br>○ Some tables and graphs are well constructed but contains some errors<br>○ Some sources are referenced correctly in the agreed format with occasional errors |
| | Language and Style | ○ No spelling, grammar or punctuation errors<br>○ Units and significant figures are presented accurately throughout<br>○ Writing style consistently clear, appropriate for scientific documents and easy to follow<br>○ Accurate and consistent use of technical language and vocabulary | ○ Minimal spelling, grammar or punctuation errors<br>○ Units and significant figures are presented accurately throughout<br>○ Writing style mostly clear, appropriate for scientific documents and easy to follow<br>○ Some attempts of using technical language and vocab alary, but not always accurate | ○ Some spelling, grammar or punctuation errors<br>○ Units and significant figures are presented accurately throughout with occasional errors<br>○ Writing style moderately clear, appropriate for scientific documents and easy to follow<br>○ Use of simple language and vocabulary effectively but struggles to use technical language |

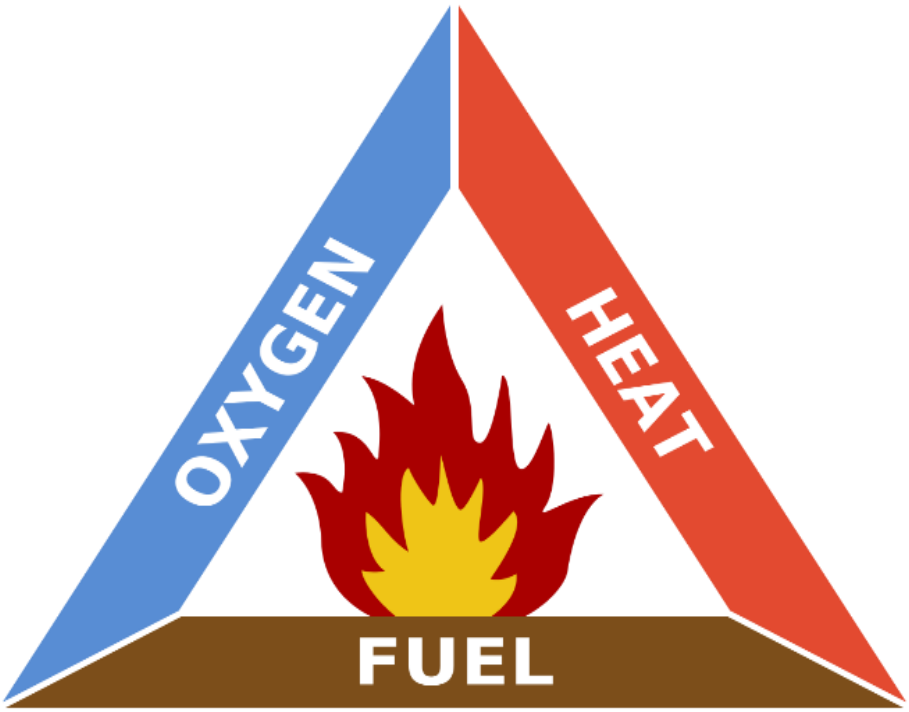
# Glossary of Keywords

| Word | Definition | In a sentence |
|---|---|---|
| Air fuel ratio | | |
| Calorific value | | |
| Chemical energy | | |
| Chemical equation | | |
| Combustion | | |
| Compression ratio | | |
| Efficiency | | |
| Emissions | | |
| Energy | | |
| Energy balance | | |
| Energy assessment | | |
| Energy audit | | |

| | | |
|---|---|---|
| Energy efficiency | | |
| Fuel power | | |
| Heat loss | | |
| Hydrocarbon | | |
| Indicated power | | |
| Indicated thermal efficiency | | |
| Internal combustion engine | | |
| Mass flow rate | | |
| Power | | |
| Recovery | | |
| Sankey diagram | | |
| Self-ignition | | |
| Specific fuel consumption | | |

| | | |
|---|---|---|
| Stoichiometric air-fuel ratio | | |
| | | |

# Tutorial 1 – What is combustion?



## What is the Purpose of Tutorial 1?

- To introduce the tutor and the course
- To identify pupils prior knowledge and misconception on the subject of combustion
- To understand the meaning of combustion
- To understand some basic terminologies associated with combustion
- To understand the general chemical equations of combustion

## Activity 1: Refresher – What is combustion?

In 60 seconds and working independently, write down everything you know about combustion in the space given below.

- Examples
- definition
- Types
- Applications
- Features or characteristics
- Conditions for occurrence

In another 60 seconds, share your answers with the person next to you. Do both of you have any similar answer? Are there points noted down by your partner that you have not thought of?

## Activity 2 – Condition necessary for combustion

Demonstration on why air is necessary for combustion

Light a candle and after some time, cover the candle with a glass cylinder or glass tumbler. The light on the candle will be seen flickering and finally quenched. Light the candle again and after some time cover it with the beaker. While the light is going down, remove the beaker and the light would be seen to rise again.

In 60 seconds discuss with a partner what you think is responsible for the above observation. One person from each pair or group should be prepared to present their thought to the entire class.

## Activity 3 – Self-ignition temperature

This is the minimum temperature for a substance to ignite (catch fire).

Demonstration

Heat up two paper cups (one empty and the other filled with water) for some time using two separate burning candles and closely observe what happens to the two cups. In 60 seconds discuss with a partner why you think one of the cups starts to burn at some point why the other does not.

## Activity 4: Chemistry of combustion

What are hydrocarbons? Write down the name of any four hydrocarbon fuels you know and their chemical formula.

Write down the balanced chemical equation for the complete and incomplete combustion of methane fuel.

Complete combustion

$CH_4 + O_2 = --- + ----$

Incomplete combustion

$CH_4 + O_2 = --- + --- + --- + --$

What is stoichiometric air-fuel ratio?

## Tutorial 1 Homework: Baseline test

Purpose of baseline assignment: This test is meant to see where you are in terms of the skills and subject knowledge you have acquired. It will help you and your PhD tutor to know where you are in terms of your journey towards their final assignment
And help identify where we need to focus on in the upcoming tutorials.

Do not worry too much about your performance in the baseline test as it takes into account that you may not be familiar the subject area.

1. Explain what you understand by Lean combustion (lean burn) and rich combustion (rich burn). Assuming you are a combustion engineer, would you run your petrol engine under lean burn or rich burn condition? Give reasons to support your choice.

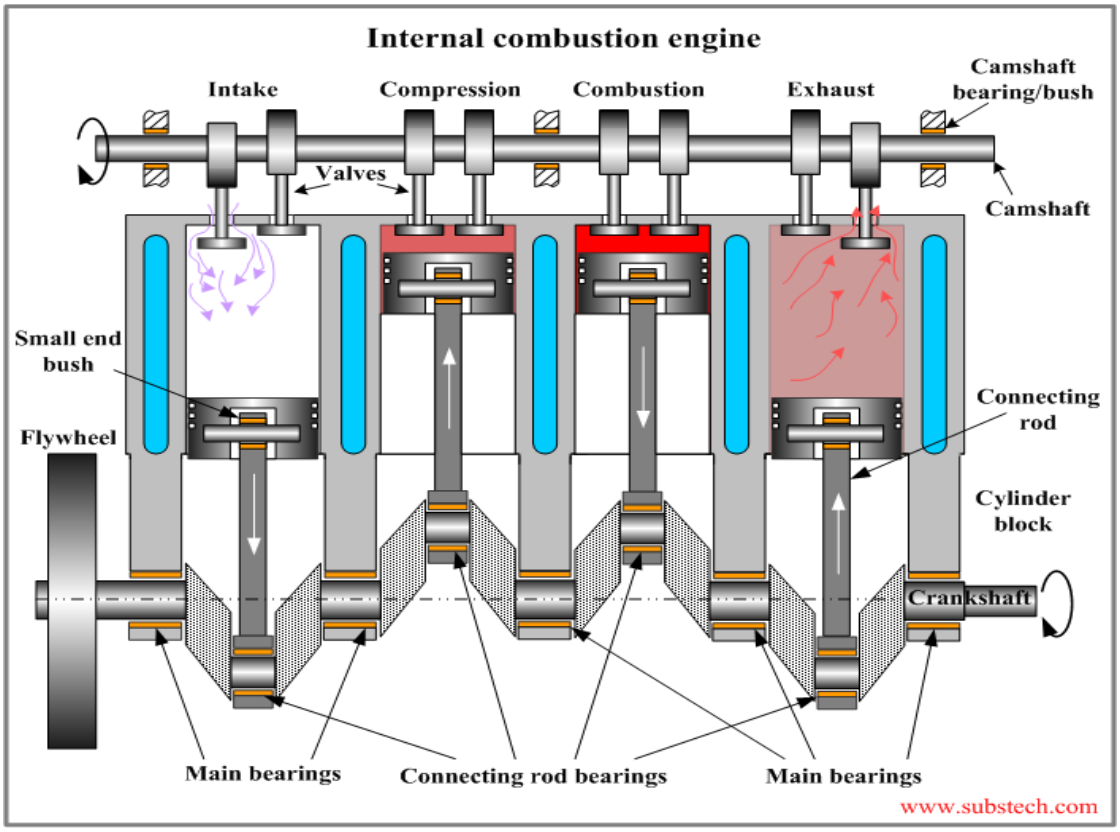
2. Compare 'complete' and 'incomplete' combustion. Write down the complete and incomplete combustion equation of propane. How do you think the incomplete combustion of propane in a combustion device (i.e. boiler) would affect the fuel economy, the environment and the energy cost of running the boiler?

3. Search out and read through a few articles from the web (i.e. journals, web pages, etc.) related to the topic 'improving the energy efficiency of the internal combustion engine'. Write a short report on the above topic and the report should address the following questions. References should be provided in the right format (see Appendix 1) for all articles used in the report.

- Why is it important to improve the energy efficiency of engines
- What is the average thermal efficiency of ICEs
- How is the energy efficiency of an engine determined?
- What is the difference between the thermal and mechanical efficiency of an ICE.
- What are the common energy sources(i.e. the type of fuel used)in ICEs
- What are the sources of heat loss in ICEs and which ones are more significant
- What are the ways energy losses can be recovered/reduced in ICEs to improve its energy efficiency.

4. An engine consumes 0.01573 kg/s of air. If the air-fuel ratio is 12/1, what is the mass flow rate of the fuel? If the calorific value of the fuel is 46 MJ/kg, calculate the fuel power.

# Tutorial 2 – Combustion process in internal combustion engines (ICE)




## What is the Purpose of Tutorial 2?

- To understand the process of combustion in a petrol engine
- To understand the process of combustion in a diesel engine
- To understand the difference between a petrol and diesel engine
- To understand the meaning of fuel power, indicated power output, indicated thermal efficiency and specific fuel consumption of an internal combustion engine and how they are determined or computed.

## Activity 1: Internal versus External combustion engines

Discuss with a partner what you understand by the term 'internal combustion engine'. How is it different from an external combustion engine? Can you provide some examples of each?

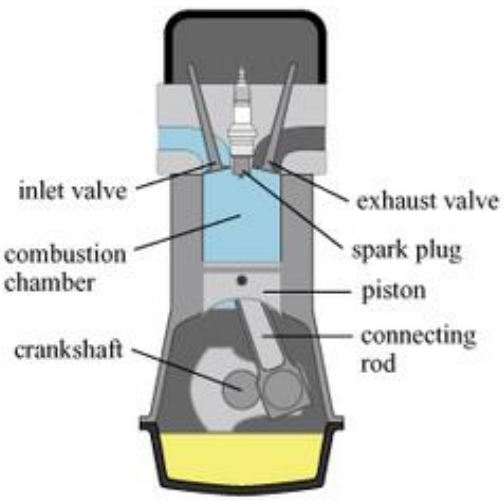
## Activity 2: Combustion process in ICE

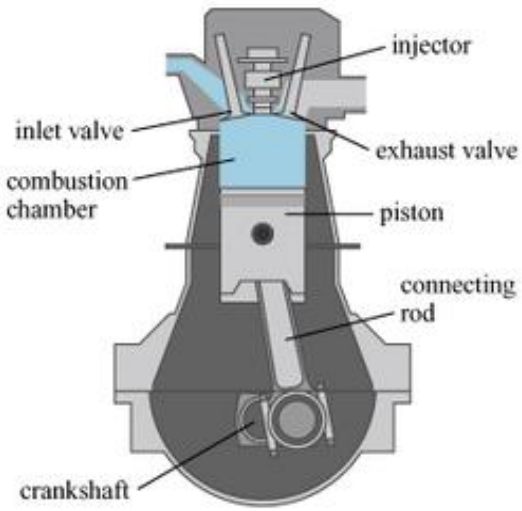
Discuss with the person sitting next to you, how you think a petrol engine works to move a vehicle. Do you agree or disagree?

You will be shown two videos from the links below on how internal combustion engines work. From the video and in addition to the two pictures shown below, identify and write down three major difference you think exist between a petrol engine and a diesel engine

https://www.youtube.com/watch?v=rlK7JIAz9WY

https://www.youtube.com/watch?v=fTAUq6G9apg&t=53s




## Activity 3: Definition of some more terms

What is the calorific value of a fuel?

What is fuel power (FP)?

Fuel power = mass of fuel flowing into engine per sec x calorific value of fuel

What is the indicated output power (IP)?

This is the power developed by the pressure of the gas acting on the piston.

What is the indicated thermal efficiency (ITE)?

Indicated thermal efficiency (ITE) = IP/FP

What is the specific fuel consumption (SFC) of an engine?
This is the mass of fuel (amount of fuel) consumed by the engine to generate I kW of power in 1 hour

SFC = $m_f$/IP

Where $m_f$ is the mass flow rate of fuel

## Activity 4: Problem solving

A 250 kW turbo charged petrol engine operate at a thermal efficiency of 0.42. Assuming the engine runs on a fuel of calorific value 40.6 MJ/kg, determine the mass flow rate of the fuel.

Fuel power = Output power/ efficiency

Fuel power = _____

Fuel power = $m_f$ x CV

$m_f$ = _____

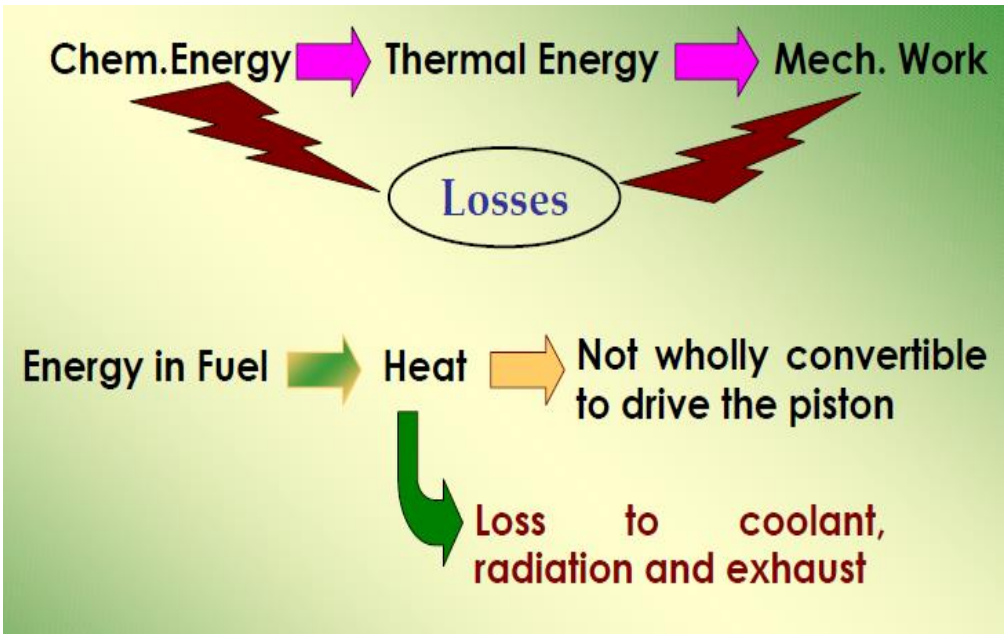
## Tutorial 2: Homework

1. Mention 6 industries where the combustion of fuels plays a very important role

2. In each of the industries mentioned in question 1 above, mention the device or system in which the combustion process takes and explain the function of the combustion device in that industry.

3. Using the example given in activity 4, calculate the specific fuel consumption (SFC) of the engine. Will the SFC of the engine increase or decrease as the efficiency of the engine is improved? Give the reason for your answer.

# Tutorial 3 – Energy-balance: How it works



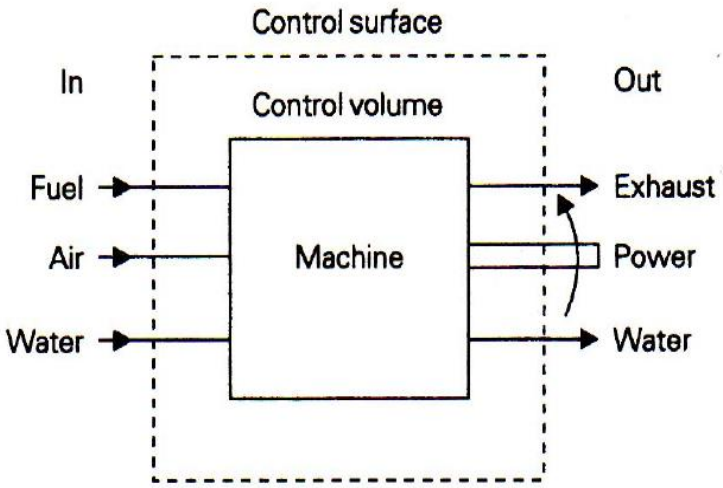

## What is the Purpose of Tutorial 3?

- To understand the steps involve in carrying out the energy-balance of a combustion device
- To understand how to write an energy balance equation and prepare an energy-balance sheet
- To introduce pupils to the Sankey diagram

## Activity 1: First step when performing an energy balance?

What do you think should be the first thing to do when carrying out an energy balance of any combustion device? Think about this in 30 seconds and be ready to feed back to the rest member of the group.

You have 60 secs to study the schematic diagram shown below which represent the energy flow in a gasoline engine. Take note of the different energy streams (sources), i.e., energy flowing into and leaving the engine. Can you identify and explain any three ways energy is lost in the engine. In what way are these losses directly or indirectly link to environmental pollution?




## Activity 2: Calculating energy flows

To understand the formulas for calculating the energy flowing into and out of an engine.
In 60 seconds, look at the terms provided in equations 1-6 below. Do you understand the meaning of the terms? Choose any of the equations you understand its terms and be ready to feedback to the rest of the group.

Is there anything common between equations 3-5? In another 60 seconds discuss with a partner what you think is common between the equations

Heat energy supplied by fuel $Q_f = m_f \times CV$ 1

Where CV is the calorific value of the fuel

Heat absorbed for useful work = output power = $Q_p$ 2

Heat energy stored in a mass of flowing fluid = mass of fluid flowing per sec x specific heat capacity of fluid x temperature of fluid

Heat energy supplied by combustion air $Q_a = m_a \times c_a \times T_a$ 3

Where $T_a$ is the temperature of the combustion air

Heat energy rejected to cooling water $Q_w = Q_{wo} - Q_{wi} = m_w \times c_w \times (T_{we} - T_{wi})$ 4

Where $T_{we}$ and $T_{wi}$ are the exit temperature and inlet temperature of cooling water respectively

Heat Energy carried away by exhaust gas $Q_g = m_e \times c_e \times T_g$ 5

Where $T_g$ is the temperature of the exhaust gas
$M_e = m_f + m_a$
$Ce = Ca$

Unaccounted heat energy losses (e.g. energy losses via radiation, convection, mass leakages etc.) = $Q_{un}$

In equations 1-5, m represent mass flow rate while c is specific heat capacity

Energy balance equation

$Q_f + Q_{ca} = Q_p + Q_e + Q_w + Q_{un}$ 6

$Q_{un} = Q_f - (Q_p + Q_e + Q_w)$ 7

Efficiency of Engine = $(Q_p/Q_f) \times 100$

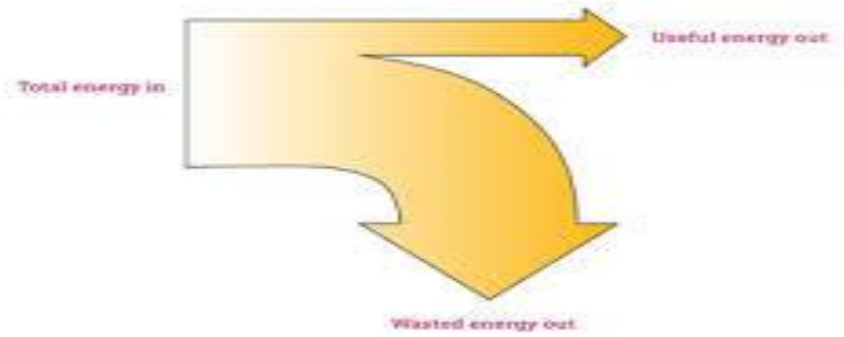
## Activity 3: Preparing an energy balance sheet

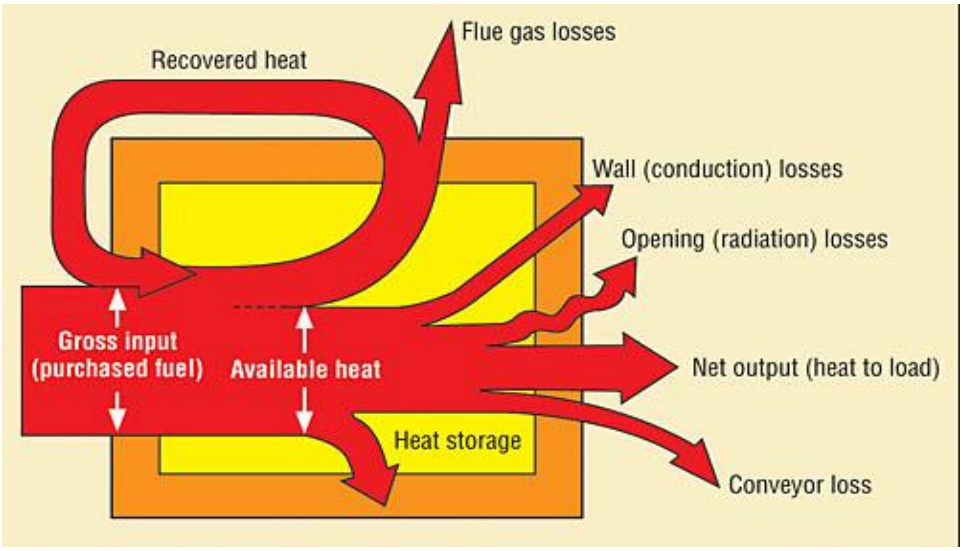
Complete column 1 and 4 of the table given below with the missing item.

| ENERGY IN | | | ENERGY OUT | | |
|---|---|---|---|---|---|
| | Unit (KW) | percentage | | Unit (KW) | percentage |
| Fuel | | | ---------- | | |
| ---------- | | | Exhaust gases | | |
| | | | ---------- | | |
| | | | Energy Unaccounted for | | |
| | | | | | |

## Activity 4: Introduction to the Sankey diagram

All of the energy flows in a combustion device can be categorised as 'total energy in', 'useful energy out' and 'wasted energy out' as shown in the top figure below. Categorise all the energy flows shown in the figure below under these three headings.



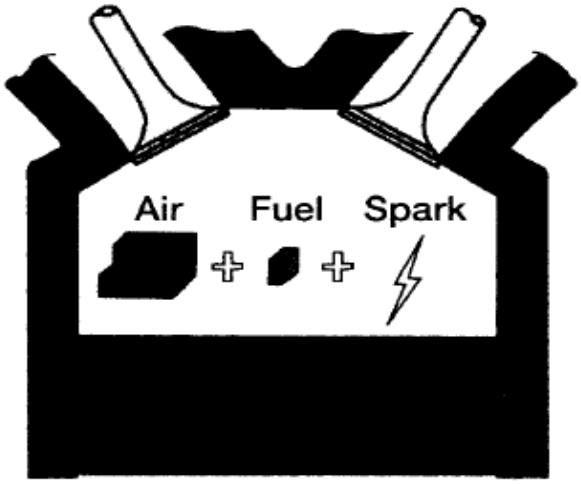
## Tutorial 3: Homework

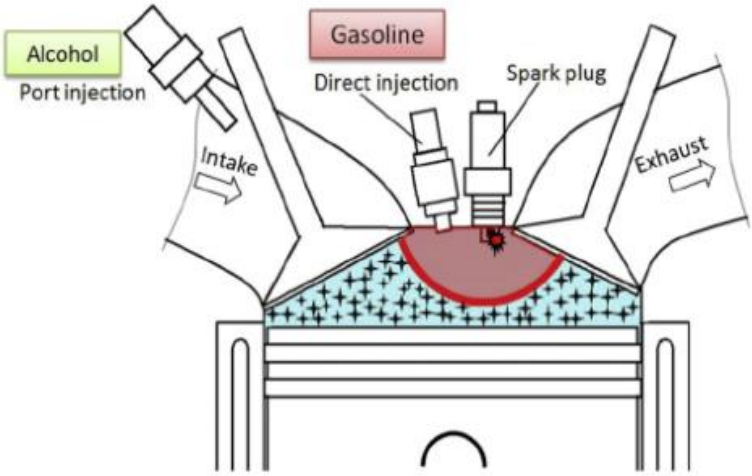
1. The following activities are part of the process for assessing the energy performance of a combustion device for improvement of its efficiency. Put the activities in the right order that they should be performed.

- Draw the Sankey diagram
- Calculate the size of each energy flows
- Identify the energy flowing in and out of the combustion device
- Determine the efficiency of the combustion device
- Implement cost effective energy recovery option
- Prepare the energy balance sheet
- Identify the areas of high energy losses
- Recommend techno-economic solutions for energy recovery

2. Fred's petrol engine takes in 2000 J of chemical energy and does 400 J of work. How efficient is the engine?

# Tutorial 4: Case study of gasoline engine




## What is the Purpose of Tutorial 4?

- To prepare an energy balance sheet Sankey diagram for a gasoline engine and draw it's
- To understand the importance of energy efficiency in a wider context

## Activity 1: Problem solving

The data giving in the table below was collected for a 36.8 kW gasoline engine. Use the information provided to prepare the energy balance and Sankey diagram of the engine.

| | |
|---|---|
| Engine speed | 3125 rev/min |
| Power output | 36.8 kW |
| Fuel consumption rate | 0.00287 kg/s |
| Air consumption rate | 0.04176 kg/s |
| Lower calorific value of fuel | 41.87 X $10^6$ J/kg |
| Exhaust gas temperature | 1066 K (793 $^{O}$C) |
| Cooling water flow rate | 0.123 kg/s |
| Cooling water inlet temperature | 282.2 K (9.2 $^{O}$C) |
| Cooling water outlet temperature | 345.8 K(72.8 $^{O}$C) |
| Inlet air temperature | 292 K (19 $^{O}$C) |
| Specific heat capacity of air and exhaust gas | 1.00 kJ/kgK |
| Specific heat capacity of water | 4.18 kJ/kgK |

Heat energy supplied by fuel $Q_f$ = 0.00287 x 41870000 = _____

Heat absorbed for useful work = Power output = $Q_p$ = 36.8 kW

Heat energy supplied by combustion air $Q_a$ = 0.04174 x 1.00 x 292 = _____

Heat energy rejected to cooling water $Q_w$ = 0.123 x 4.18 x (344.8 – 281.2) = _____

Heat Energy carried away by exhaust gas $Q_g$ = (0.00287+0.04176) x 1.0 x 1066 = _____
Where $M_e = m_f + m_a$ and

Ce = Ca

Unaccounted losses $Q_{un} = Q_f - (Q_p + Q_e + Q_w)$ = _____

Efficiency of Engine = $(Q_p/Q_f)$ x 100 = _____

## Activity 2: Energy balance sheet

Complete the energy balance table shown below and place the values of the energy flows computed in activity 1 in the appropriate columns. Share your table with a partner. Is there any difference between your tables?

| ENERGY IN | | | ENERGY OUT | | |
|---|---|---|---|---|---|
| | Unit (KW) | percentage | | Unit (KW) | percentage |
| | | | | | |
| | | | | | |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| Total | | | Total | | |

## Activity 3: Drawing the Sankey diagram

Use the information in the energy balance sheet prepared in activity 2 above to prepare the Sankey diagram showing the energy flow in the gasoline engine

## Activity 4: Extract- Energy assessment

Below is an extract from an article published in the NSE Journal of Technical Transactions in 2010. Make a note of any term you are unfamiliar with. Provide a title for the extract. Then summarise 2-3 key points of the extract and be ready to feed back to the rest of the group.

*"The cost of fuel has risen remarkably in recent years. In most energy intensive sectors, the energy cost takes up substantial share in the overall cost structure of the operation (Phubalan, 2007). The production process in most manufacturing industries is an energy intensive process. Therefore, effective use of energy is necessary to cut down energy cost to ensure that manufacturers remain competitive (Glass Best Practices, OIT, 2002).*

*In addition to saving money, energy efficiency or conservation is also an essential step being currently taken toward overcoming the mounting problems of world-wide environmental pollution and global warming (UNIDO and MITI, 1993).*

*Apart from the more obvious improvements in the house keeping aspects of factory practice, most effective savings are usually made in the high energy consuming areas. Thus, it is imperative that detailed energy audit should focus on specific systems and major equipment like steam system, compressed air system, heat generators (i.e. furnaces, boilers, internal combustion engine), heat recovery system, air-conditioning system etc. (Gottschulk,1996).*

*Energy audit or assessment as a tool for energy management is a systematic study or survey to identify how energy is being used in a building or plant and identifies energy saving opportunities.*

*An energy audit or assessment provides essential information on how much, where and how energy in the form of electricity, gas, fuel oil or steam is used within a factory or building or system during a fixed period. This will indicate the performance at the overall plant or process level. The energy manager can therefore compare these performances against past and future levels for a proper energy management"*

## Tutorial 4: Homework

1. Which car is most efficient for you?

Carefully watch the video provided in the link below titled 'Which car is most efficient for you. Using a table, rank the various types of car described in the video in an order of which is most efficient. Provide a brief explanation to support your choice.

https://www.greencarguide.co.uk/which-car-is-most-efficient-for-you/

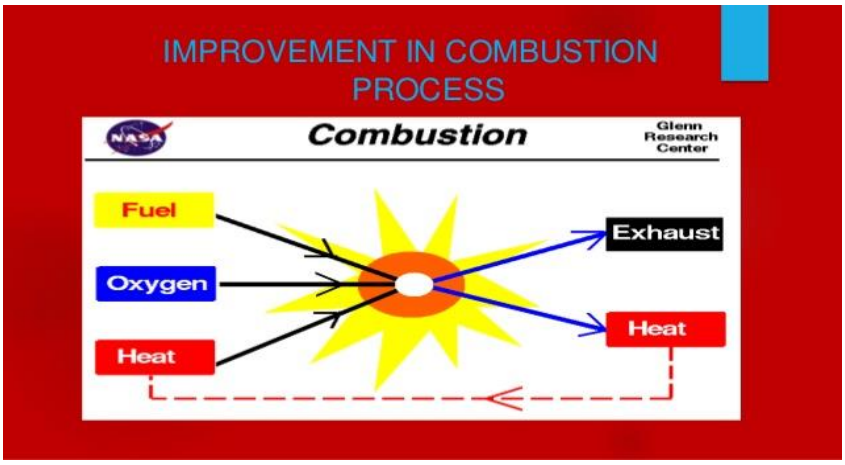
| Car type in order of energy efficiency | Notes |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |

2. You will be given an extract from an articles published in the NSE Journal of Technical Transactions in 2011. Make a note of any term you are unfamiliar with. Provide a title for the extract and then summarise 2-3 key points of the article.

From the table provided in the article, answer the following questions

a. Use a pie chart to represent the information in the table in terms of the potential energy saving and $CO_2$ reduction
b. State the sectors with the minimum and maximum energy savings. What is the correlation between the energy savings and the $CO_2$ reduction in these sectors?

# Tutorial 5 –Review and reflection




## What is the Purpose of Tutorial 5?

- Prepare for the assignment
- Review previous tutorials
- Question and answer

## Activity 1

We are now coming to the end of the course. Review what we have covered so far and summarise everything you learned in the past four tutorials in 5 sentences, 5 keywords and 2 pictures

## Activity 2: Reflection on Tutorial 4 homework

(Related to part A of final assignment)

What went well?

1.

2.

What could be improved?

1.

2.

## Activity 3: Questions and answer

a. Write down three questions relating to the course, scrunch them up and place them in the middle. Questions can be related to something you are unsure about or something to test others knowledge

b. Take turns to pick a question from the middle and ask the rest of the group

## Tutorial 5: Homework- Final Assignment

Total word count = 2500 words (part A is 1500 words and part B is 1000 words)

### Part A: The BMW case study

Unfortunately, from the very beginning the focus on an internal combustion engine has been on producing more power rather than providing a better fuel economy, but nowadays due to growing awareness of environment and rising oil prices, engineers have shifted their attention on to producing more fuel efficient engines. For example, BMW is researching on ways to increase the fuel efficiency of a conventional engine by 10-15 percent by looking to recover and reuse heat energy lost through the exhaust and that absorbed by the engine cooling system. With such initiatives we can see a future of more efficient and more environmentally friendly engines.

(i) In a maximum of 150 words, write a summary of everything you know about the internal combustion engine. Think about the definition, history, examples, types, operation, anything else.

(ii) Read the article provided below which highlights BMW's research effort towards increasing the fuel efficiency of diesel and gasoline engines. Write a summary of the article explaining the key points and the impact the research could have on energy cost and the environment.

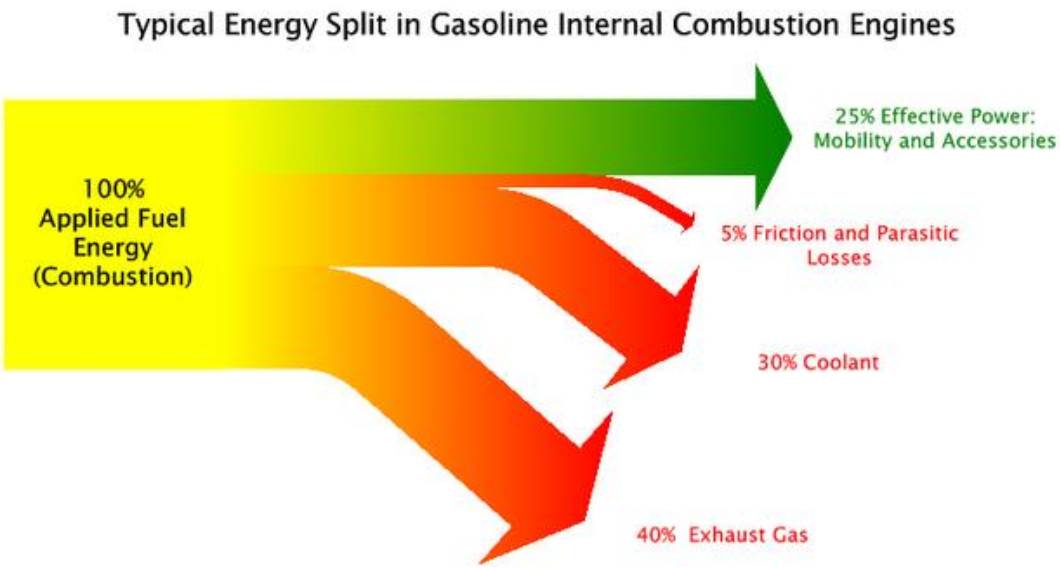
https://www.greencarguide.co.uk/2011/08/bmw-to-use-engine-heat-losses-to-gain-10-15-fuel-economy/

Some key points to consider in the summary include:

- What is the efficiency of current engines? I.e. The percent of fuel energy that is converted to useful work and the percentage that is lost.
- What are the heat loss sources BMW is focusing on for efficiency improvement?
- What method is BMW employing for improving energy efficiency and how does it work?
- What is the predicted fuel economy gain based on BMW's design?
- What is the fuel consumption and $CO_2$ emission reduction has BMW's design currently achieved based on customer testing?

Part B: Energy Balance scenario

A Sankey diagram is shown below for a petrol engine. It gives a diagrammatic picture of the energy flows in the internal combustion device. The width of each arrow is equivalent to the size of the energy flow involve. Study the diagram and answer the following questions.




1. Where do the highest energy loss occur in the engine?
2. In your opinion is the engine operating efficiently? Give the reason for your answer
3. If the fuel power for the engine discussed in activity 4 of this tutorial was 8500 kW, using the Sankey diagram given in activity 4, prepare an energy balance sheet of the engine.
4. From the Sankey diagram, what is the efficiency of the engine? Explain why the efficiency is not 100 percent
5. If the calorific value of the fuel is 32 MJ/kg, determine the specific fuel consumption of the engine. Apart from the method of recovering the energy loss in the engine, what are the other things a car owner can do to improve the SFC of their car. Rank your 5 top methods. The following link might be useful: https://www.theglobeandmail.com/globe-drive/culture/commuting/20-ways-to-improve-your-cars-fuel-efficiency/article1379796/

# Tutorial 6 – Feedback tutorial

## What is the Purpose of Tutorial 6?

- To receive feedback on final assignments.
- To share examples of best practice with the other pupils in your group.
- To write targets for improvement in school lessons.
- To reflect on the programme including what was enjoyed and what was challenging.

## Final assignment feedback

| What I did well… | What I could have improved on… |
|---|---|
| • | • |
| • | • |
| • | • |

| My target for future work is… |
|---|
| |

## Reflecting on Uni Pathways

| What did you most enjoy about Uni Pathways? |
| --- |
| • <br>• <br>• |

| What did you find challenging about the programme? | How did you overcome these challenges? |
| --- | --- |
| • <br>• <br>• | • <br>• <br>• |

# Appendix 1 – Referencing correctly

When you get to university, you will need to include references in the assignments that you write, so we would like you to start getting into the habit of referencing in your Brilliant Club assignment. This is really important, because it will help you to avoid plagiarism. Plagiarism is when you take someone else's work or ideas and pass them off as your own. Whether plagiarism is deliberate or accidental, the consequences can be severe. In order to avoid losing marks in your final assignment, or even failing, you must be careful to reference your sources correctly.

## What is a reference?

A reference is just a note in your assignment which says if you have referred to or been influenced by another source such as book, website or article. For example, if you use the internet to research a particular subject, and you want to include a specific piece of information from this website, you will need to reference it.

## Why should I reference?

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you losing marks, or failing, due to plagiarism.

## When should I use a reference?

You should use a reference when you:

- Quote directly from another source.
- Summarise or rephrase another piece of work.
- Include a specific statistic or fact from a source.

## How do I reference?

There are a number of different ways of referencing, and these often vary depending on what subject you are studying. The most important to thing is to be consistent. This means that you need to stick to the same system throughout your whole assignment. Here is a basic system of referencing that you can use, which consists of the following two parts:

1. A marker in your assignment: After you have used a reference in your assignment (you have read something and included it in your work as a quote, or re-written it your own words) you should mark this is in your text with a number, e.g. [1]. The next time you use a reference you should use the next number, e.g. [2].
2. Bibliography: This is just a list of the references you have used in your assignment. In the bibliography, you list your references by the numbers you have used, and include as much information as you have about the reference. The list below gives what should be included for different sources.

    a. Websites – Author (if possible), title of the web page, website address, [date you accessed it, in square brackets].

    E.g. Dan Snow, 'How did so many soldiers survive the trenches?', http://www.bbc.co.uk/guides/z3kgjxs#zg2dtfr [11 July 2014].

    b. Books – Author, date published, title of book (in italics), pages where the information came from.

    E.g. S. Dubner and S. Levitt, (2006) *Freakonomics*, 7-9.

    c. Articles – Author, 'title of the article' (with quotation marks), *where the article comes from* (newspaper, journal etc.), date of the article.

    E.g. Maev Kennedy, 'The lights to go out across the UK to mark First World War's centenary', Guardian, 10 July 2014.

# Appendix 2 – Using the VLE

| | |
|---|---|
| VLE username | |
| VLE password | |

Please remember the following key details…

- You are able log into the VLE either through the link on our website (www.thebrilliantclub.org) or going directly to the VLE site at (https://portal.thebrilliantclub.org/sign-in).
- Please update your profile with your full name and email address- this will allow you to retrieve forgotten passwords or usernames
- If you forget your log-in details you can request them to be emailed to you by clicking the link on the VLE home page. (If you are still having problems you can email: schools@thebrilliantclub.org)

## What is the VLE?

The VLE is a virtual learning environment for all pupils on Uni Pathways it is used for:

- messaging your tutor
- submitting homework
- submitting your final assignment
- accessing resources for your tutorials
- finding out more information about university and careers

## How should I use the VLE?

The VLE is a professional academic environment in which pupils are able to message their PhD Tutor. Here are a few things to consider:

- Ensure you keep a professional tone in the messages you send to your tutors.
- Ensure you always reply to your tutors in a timely manner.
- Thank your tutor for the effort they are putting in to give you your feedback etc.
- Submit all homework to your tutor on time.

## IMPORTANT: Final assignment

- When you submit your final assignment, please remember that you need to do so through the 'My Activities' tab and not as an attachment to a message.

# Notes

# Notes

# Notes

UNI PATHWAYS

# Course Title

## Key Stage 4 Programme

researchersinschools.org