

Report

by Oliver Overton

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Title: Resonance

Module code: ACDA4006

Declaration: The work of this report completed under the supervision of Gareth Jones. I declare that this report is the product of my own work and is not being submitted for any other degree etc.

Signature: 



Abstract:

RLC circuits propose many real life applications as oscillator circuits (circuits of which produce a periodic electronic signal often in the form of a sign wave). They can also be used as radio receivers and even professional television sets use them for tuning to find a narrow range of frequencies. However we used the RLC circuit to compare and contrast two similar circuits. One of which was a simulation on Proteus and the other was a real life practical using a picoscope. Even though the two circuits were very similar, in fact nearly identical, the results varied due to real life limitations such as internal EMF, internal impedance and internal resistance, so in real life the results were lower than the simulation. The results were also lower because Proteus does not account for elements in the circuit heating up. No circuit is 100% efficient and energy is lost as heat. When elements heat up this causes their resistance to increase, thus lowering the output data we analysed. The purpose of this practical was to also investigate the 'q factor' (the voltage magnification factor achieved across the coil and capacitor compared with the initial supply voltage).

Introduction:

A parallel RLC circuit is an electrical circuit consisting of three main elements/components, a resistor (R), an inductor (L), and also a capacitor (C), connected parallel (it is not mandatory they have to be parallel they can be series). The name of the circuit is essentially an acronym from the main letters that are used to specify the components of the circuit. In some cases RLC circuits are used for examples of simple harmonic motion (SHM). This is due to the circuit being an oscillator for the current running through the circuit (positive to negative). The circuit can also be introduced to different forms of damping. A simple standard resistor will dampen the oscillations lightly, however if you use a light dependent resistor and expose it to bright light then you can supposedly heavily damp the oscillations, although you can achieve the same affect by using a higher ohm resistor. The resistor also has one other function which is to lower the peak resonant frequency. In real life even if there is no resistor in the circuit there will always be some form of internal resistance as no circuit is 100% efficient. To achieve 100% efficiency you need extremely low temperatures to prevent elements from heating.

When it comes to analysing the data of an RLC circuit, the RLC 'filter' (called this because you can filter frequencies when tuning into narrow band widths) is described as a second-order circuit, which means that any voltage or indeed current in the circuit can be defined by a second-order differential equation.

Method (Proteus):

1. Open up Proteus from the desktop home screen.
2. Under parts search for 'RES', 'CAP' and 'Inductor'.
3. Add a battery, signal generator and oscillator.
4. Connect all components in parallel using the wire feature.
5. Press run in the lower left corner of the screen.
6. You can then change the time base on the generator and oscillator.
7. Using the 'points' marker record peak to peak voltage.

Method (Practical)

Apparatus:

- Resistor (1K Ω) – to dampen the oscillations.
- Inductor – to store electrical energy in a magnetic field.
- Capacitor – to allow it to charge across two plates.
- Voltage supply (Battery/Cell) – provide energy per unit charge.  6
- Ammeter – to measure voltage.  7
- Picoscope – this acts like an ammeter but has digital readings on software.
- Wires – to connect all components.
- Breadboard – a housing for the components on the terminal strips. Gets power once power rails are connected to the voltage supply.

Process:

1. Using the breadboard set up the components so that they make a circuit.
2. Ensure the voltage supply is connected to the power rails.
3. Ensure the components are on the terminal strips.
4. Connect the picoscope to the breadboard using the tweezer like pen.
5. Open the picoscope software on the desktop.
6. Once the circuit is connected use the red and black cable from the bag to connect the picoscope to a power source. These wires have to be twisted to secure them in place.
7. Change the frequency of the circuit.
8. Record VLC off the desktop software.

Risk Assessment:

Risk Hazard (1-5)	Potential affects (1-5)	Mitigation	Likelihood (1-5)	Overall rating
The ends of the wires are sharp once the rubber surrounding has been stripped back. (3)	The sharp ends can cause cuts and bleeding in extreme cases. In normal scenarios maybe a slight irritation of a 'prick'. (3)	Handle the wires with care. Do not strip the rubber back with your teeth. Use proper electrical scissors to strip the wires. Possibility to wear gloves.	If the mitigation advice is understood and carried out the following event is not likely. (3)	27
In the worst case scenario it is possible that the user could get a severe electric shock from the mains of 230V. (5)	The shock of this magnitude could cause irregular patterns of the heart beat and can cause irregular muscle contractions. (5)	Only switch the power on when required and when the circuit is properly connected. Use the picoscope pen by the rubber end.	The following event is not likely as everyone is competent with electronics and understands basic safety. (1)	25
The prongs of the resistor are sharp like that of the wires. The prongs are also very fine. (3)	The sharp ends can cause cuts and bleeding in extreme cases. In normal scenarios maybe a slight irritation of a 'prick'. If someone shows a friend their resistor there's chance of the prongs poking someone in the eye. (4)	Do not wave the resistor around in the air. Leave it on a flat surface when not in use. Place the resistor in the breadboard as soon as you get it.	It is not likely someone at university will poke someone in the eye as everyone is expected to be mature. However self-injury by misuse is likely. (2)	24

Caption required

Analysis:

The analysis can be done either during the practical on the dual monitor display or once the practical has been complete and packed away. It is recommended you fill in an excel sheet during the practical in order to identify any anomalous results and fix the issue rather than trying to work out what happened after you've packed away. When undergoing the practical you want to complete an excel sheet of frequency in hertz against Vin and VLC. Once this is complete you can draw a line graph on excel of frequency against VLC. A further calculation can be done from this original data of attenuation. Attenuation is a universal definition that refers to any reduction in the strength of the signal outputted from the signal generator. Attenuation normally occurs over a long distance of transmission however still occurs on a small scale in all circuits. The calculation for attenuation can be done by using the following equation. $20 \times \log_{10}(VLC/Vin)$.

Data:

Proteus			
Frequency (Hz)	Vin (V)	VLC (V)	Attenuation (dB)
100	4	2.60E-03	-6.37E+01
200	4	4.92E-03	-5.82E+01
500	4	1.27E-02	-5.00E+01
1000	4	2.60E-02	-4.37E+01
2000	4	6.05E-02	-3.64E+01
2500	4	8.88E-02	-3.31E+01
3000	4	1.19E-01	-3.05E+01
3500	4	1.84E-01	-2.67E+01
4000	4	2.90E-01	-2.28E+01
4500	4	6.50E-01	-1.58E+01
5000	4	3.20E+00	-1.94E+00
5500	4	6.00E-01	-1.65E+01
6000	4	3.50E-01	-2.12E+01
6500	4	2.50E-01	-2.41E+01
7000	4	2.00E-01	-2.60E+01
7500	4	1.61E-01	-2.79E+01
8000	4	1.29E-01	-2.99E+01
8500	4	1.10E-01	-3.12E+01
9000	4	1.08E-01	-3.14E+01
9500	4	8.80E-02	-3.32E+01
10000	4	8.40E-02	-3.36E+01
20000	4	3.40E-02	-4.14E+01

After using the above stated equation you can see the general trend of the data for attenuation. From 100Hz to 4500Hz the attenuation increases up until around 5500Hz where it starts to decrease again. At 5000Hz there appears to be an anomalous result however I have not discarded it as it may be due to something uncontrollable in Proteus.

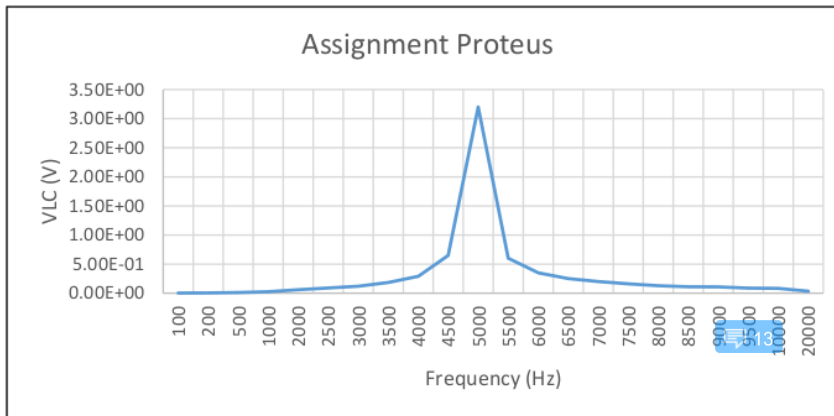


Figure 1.

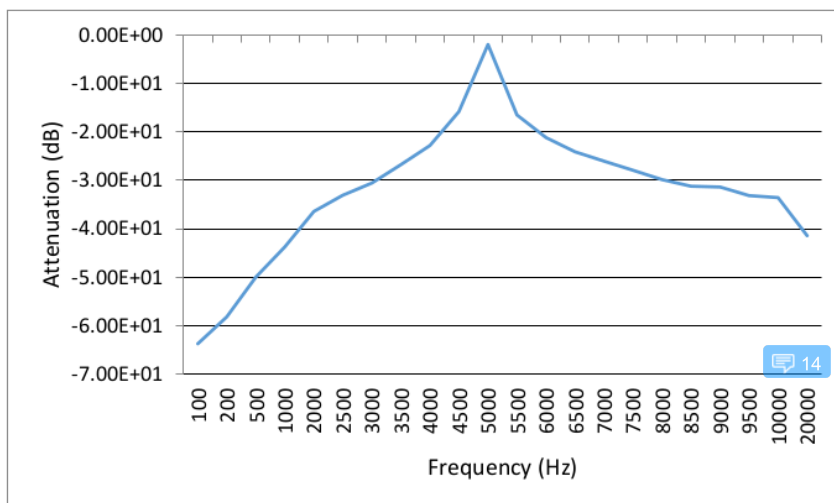


Figure 2.

In Figure 1 you can see the trend more easily as the data is plotted as a line graph. From 100Hz to 3500Hz the VLC increases at a steady rate until 4000Hz where it increases dramatically. The VLC peaks at 5000Hz, then follows the pattern in the negative reciprocal. However the VLC takes longer to drop than it did to increase.

For Figure 2 where attenuation is plotted against frequency you can see the almost exponential increase in attenuation. However it follows a similar trend to that of VLC against frequency. Again the peak is at 5000Hz. As this is a simulation where no internal resistance EMF or impedance occurs we can expect the picoscope graphs to have lower values at each frequency interval and a lower peak of VLC.

Picoscope			
Frequency (Hz)	Vin (V)	VLC (V)	Attenuation (dB)
100	4	6.23E-03	-5.62E+01
200	4	1.15E-02	-5.08E+01
500	4	2.11E-02	-4.56E+01
1000	4	2.64E-02	-4.36E+01
2000	4	4.46E-02	-3.91E+01
2500	4	5.95E-02	-3.66E+01
3000	4	7.96E-02	-3.40E+01
3500	4	1.12E-01	-3.10E+01
4000	4	1.63E-01	-2.78E+01
4500	4	2.43E-01	-2.43E+01
5000	4	2.84E-01	-2.30E+01
5500	4	2.29E-01	-2.48E+01
6000	4	1.68E-01	-2.76E+01
6500	4	1.30E-01	-2.97E+01
7000	4	1.06E-01	-3.15E+01
7500	4	1.05E-03	-7.16E+01
8000	4	9.64E-04	-7.24E+01
8500	4	9.52E-04	-7.25E+01
9000	4	1.01E-03	-7.20E+01

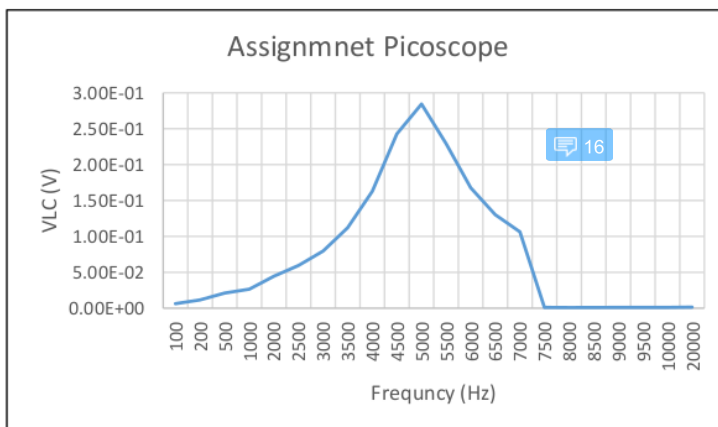


Figure 3.

If we take the first value for VLC at 100Hz from the picoscope data and compare it to the data from the Proteus simulation we can see we are **3.63e-03 out of phase**. The decrease in the picoscope practical is due to internal impedance. The impedance is the same as the internal resistance of the source. By this I mean the sum of all the internal resistances of all the components including the wires. Essentially the longer the circuit the more impedance. When the power source provides current at the very start of the circuit, the measured voltage output is lower than the no load voltage. This difference between the two results is also known as the voltage drop caused by the internal resistance/impedance.

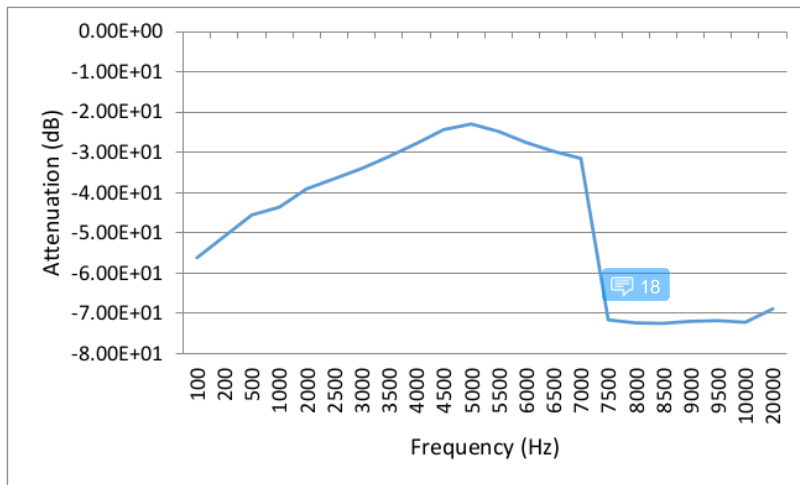


Figure 4.

Figure 4 is a graph of attenuation against frequency. The attenuation increases almost linearly, unlike the proteus simulation that had a sudden rapid increase in attenuation at around 2000Hz. Both circuits had a peak at 5000Hz however after this peak the picoscope is affected by a huge drop at 7000Hz. The reason why the picoscope sees a drop in attenuation could be because the circuit included lower loss materials. The proteus simulation was using 'perfect' components however the picoscope is not cheap and therefore would be made from low loss attenuation materials that proteus doesn't take into consideration. However the effects could be due to linear or nonlinear affects. Nonlinear effects affects a difference in proportion to the signal's overall power, "not the distance, and become the limiting factor in optical design as bandwidth capacity increases, requiring higher power for transmission." (Mulugu, 2014)

20

Real life components compared to a simulation:

There are two different types of electrical components, real and ideal. Real devices can be monitored and measured with ammeters etc. They are the components that actually exist in real life. Essentially they make up the hardware of the circuit, this includes the wires which most people forget about.

Ideal components are mathematically based simulations of specific circuit components that have precise readings/values. Simulators such that of proteus can only simulate the actions of ideal devices. "The formalism and power of circuit theory apply only to ideal devices. Models are composed of combinations of ideal devices." (Bogatin, 2003)

The difference between the two is due to 3 main limiting factors of real life components. Internal resistance, internal impedance and EMF are all ways real life circuits lose energy, most commonly in the form of heat. When components heat up this also causes the resistance to increase. This is because of the flow of electrons. As electrons move through a metal conductor (wires, resistors etc.), some collide with the internal atoms of those components/conductors, other electrons or impurities such as miniscule cracks and faults. These collisions cause resistance and generate heat due to friction building up. Heating the metal conductor causes atoms to vibrate more as their bonds break and overcome the electrostatic forces holding them in place, which in turn makes it more difficult for the electrons to flow, increasing resistance. It is an example of positive feedback where the other event causes the change to increase away from the equilibrium.

21

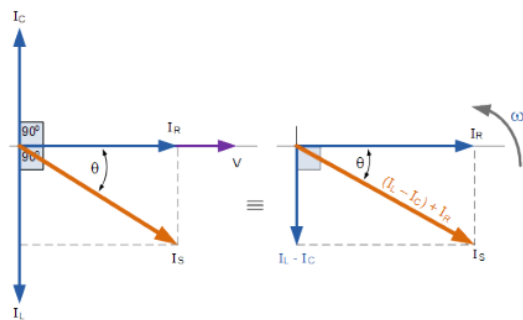
EMF (electromotive force) is a measurement of the energy (produced from a battery) that 'forces' current to flow through a circuit from the positive terminal in a battery to the negative. It can also be defined as the potential difference in charge between two points in a circuit however it is normally measured within a battery. Electromotive force is also known as internal voltage, and it is measured in volts. It is essentially the mathematical reasoning for no component being 100% efficient.

In the real life components these factors will always be limiting, thus meaning that the values experienced in real life will always be lower than that of the values gained from a simulation. The rising limb of the graphs of that of the picoscope should be lower and have a less steep gradient. From my data the outcomes were all expected besides that from the descending limb for the attenuation graph of the picoscope.

Conclusion:

22

"We can see from the phasor diagram below that the current vectors produce a rectangular triangle, comprising of hypotenuse I_S , horizontal axis I_R and vertical axis $I_L - I_C$. Hopefully you will notice then, that this forms a Current Triangle and we can therefore use Pythagoras's theorem on this current triangle to mathematically obtain the magnitude of the branch currents along the x-axis and y-axis and then determine the total current I_S of these components as shown." (Parallel RLC circuit analysis, n.d.) Having learnt this simple yet effective vectors trick, means I can complement my knowledge in physics to solve vectors with Pythagoras theorem.



(Parallel RLC circuit analysis, n.d.)

Overall from this practical we have learnt the ways in which ideal and real components differ from one another. In particular the internal impedance from components being summed together to find the overall resistance within a circuit. From this we can compare the results from a real life practical and a simulation. We saw the simulation had higher values because there was no loss of energy per unit charge (voltage) due to the lack of attenuation in a simulation. We also learnt about Q factor. Q factor is a measure for the signal quality of an optical path that takes into account the effects of noise, interference, filtering, and linear/nonlinear distortions on the pulse shape. The Q factor is a very small number so it is hard to calculate, however it can be done by saying Q is equal to the relative amplitude of the whole system/circuit at peak resonance. Therefore, if we find the peak to peak amplitude frequency relation for a constant oscillation for a range of frequencies (in our case 100Hz-20000Hz) from dc to a frequency higher than the resonant frequency, $Q = \frac{\beta_r}{\beta_{min}}$ can be found at the resonant frequency. As the measurement must cover large frequency range and the amplitude may change by several orders of magnitude, the measurement is often time consuming and inaccurate. However on proteus and the picoscope software you could change the time base of the graphs and use pin point accurate cursors to record peak to peak voltage. This meant it could be done within the given time and done accurately to a certain extent. So overall the calculated Q factor for the picoscope was lower than that of the Q factor for the simulation. This is because Q factor is independent of capacitance and voltage because we set the simulation to have the same V_{in} , inductance and capacitance as the real life practical. Meaning the only readings to significantly affect the Q factor calculation was the VLC which we now know is lower in real life due to impedance.

References:

Bibliography

Bogatin, E. (2003, December 23rd). Signal Integrity, Impedance and Electrical Models.

Retrieved from InformIT:

<http://www.informit.com/articles/article.aspx?p=102225&seqNum=3>

Mulugu, V. J. (2014). Signal attenuation. Retrieved from Science direct:

<https://www.sciencedirect.com/topics/computer-science/signal-attenuation>

Parallel RLC circuit analysis. (n.d.). Retrieved from Electronicstutorials:

<https://www.electronics-tutorials.ws/accircuits/parallel-circuit.html>

Other websites used as a reading source:

1. https://en.wikipedia.org/wiki/RLC_circuit - 24/11/2019, used to recap the basic components of an RLC circuit.
2. <https://www.electronics-tutorials.ws/accircuits/series-circuit.html> - 24/11/2019, used to look at the analysis of RLC circuits.

Books: Author: Meizhong Wang Source: Understandable Electric Circuits, 2010 Publication date: January 2010

Ref Qual 

Refs missing info 

Report

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

38/100

PAGE 1

PAGE 2



Comment 1

You do not need to include a declaration for assignment work

PAGE 3



Comment 2

1. I do not believe the components heated up sufficiently to cause this effect. This would take a significant temperature rise.
2. When writing technical reports, always use the third person passive voice. Avoid the use of "I" and "We", instead use phrases such as "it was found that...."



Comment 3

If the sentence in the brackets is important enough for you to include in your report then it does not need brackets.



Comment 4

Do you mean it reduces the resonant frequency? Or it reduces the amplitude at the resonant frequency?

You need to say what you mean



Comment 5

Yes, but don't stop here - I want you to write more now.

PAGE 4



Comment 6

No, this wasn't used.



Comment 7

Ammeters do not measure voltage - they measure current. You used an oscilloscope.



Comment 8

Your method reads like an instruction manual. You only need to state what you have done, you do not need the minute detail you have included.

All you need to do is say WHAT you did, you don't need to say HOW.

This is all you really needed:

"The circuit was connected as shown in Figure 1. The input and capacitor voltages were measured at a range of frequencies, and plotted. The -3dB bandwidth was estimated from the graphs and Q-factor calculated using Equation 1. The process was repeated for both the practical and simulated circuits."

You should try to be as concise as possible.

PAGE 5

QM

Caption required

You should always include a caption on figures, equations and tables to allow you to refer to them in your text.

e.g. An illustration of this can be seen in figure 2. The relationship of the variables is shown in equation 2. Table 1 shows the results of the first experiment where the control variable, temperature in degrees celsius is shown in the first column....

PAGE 6



Comment 9

Who is this recommendation for?



Comment 10

This seems to be an instruction list telling someone how to analyse the data. You are supposed to analyse the data.

QM

Caption required

You should always include a caption on figures, equations and tables to allow you to refer to them in

your text.

e.g. An illustration of this can be seen in figure 2. The relationship of the variables is shown in equation 2. Table 1 shows the results of the first experiment where the control variable, temperature in degrees celsius is shown in the first column....



Comment 11

Third person passive voice required.

"After applying the equation, it can be seen that the general trend....."



Comment 12

This is not anomalous, it is called resonance.

PAGE 7



Comment 13

This is the wrong type of graph. You should use an XY scatter graph with a logarithmic x-axis , not a line graph. The distance between the points on the X-axis of your graph are wrong because you have used the wrong type of graph. This makes proper analysis difficult if not impossible.



Comment 14

See comment for graph in fig.1



Comment 15

The simulation did not take into account the internal resistance of the signal generator or DC resistance of the inductor, but it does take into account EMF (ElectroMotive Force aka voltage) and impedance.

PAGE 8

QM

Caption required

You should always include a caption on figures, equations and tables to allow you to refer to them in your text.

e.g. An illustration of this can be seen in figure 2. The relationship of the variables is shown in equation 2. Table 1 shows the results of the first experiment where the control variable, temperature in degrees celsius is shown in the first column....



Comment 16

See comment for graph in Fig 1.

Why is this graph flat after 7500 Hz?



Comment 17

1. Missing units - 3.63×10^{-3} what's out of phase?
2. How are you able to measure phase difference between the two circuits with one oscilloscope probe and one circuit built in a simulator?

PAGE 9



Comment 18

I suspect you have a data handling issue from 7500 Hz onwards.

See comment from graph in Fig 1



Comment 19

I suspect something happened to your practical circuit during the experiment, such as a wire coming out of the breadboard.



Comment 20

You should be citing reference sources using the IEEE reference style. More information on this is available from the university library website.

PAGE 10



Comment 21

This is background research and should be in the introduction and it should also have references cited to support your claims.



Comment 22

A rectangular triangle? Is this some kind of new geometrical breakthrough?

PAGE 11



Comment 23

Where does this equation come from?



Refs missing info

Some of your references are missing information. To understand what information should be

included, see the university IEEE referencing handbook on the library website.

https://uwtssd.ac.uk/media/uwtssd-website/content-assets/documents/library-and-learning-resources/infoskills/IEEE-eng_v.1.2.pdf

Additional Comment

You should use IEEE reference style, not Harvard.

QM

Ref Qual

You should try to use more high quality reference sources, such as textbooks from reputable academic publishers and articles from peer reviewed journals.

Additional Comment

Do not use websites like wikipedia as these can be edited by anyone and therefore not credible in an academic sense.

GRADING FORM: SMU GENERIC_SMOSEY

OLIVER
OVERTON

37.85

ENGAGEMENT WITH LITERATURE

including reading, referencing, academic conventions and academic honesty



References to a limited range of mostly relevant sources. Some omissions and errors. Referencing conventions evident though not always applied consistently.

2

KNOWLEDGE & UNDERSTANDING

Knowledge of the basic underlying concepts and principles of a subject.



Gaps in knowledge, with only superficial understanding. Some significant inaccuracies.

10.5

COGNITIVE & INTELLECTUAL

Evaluate underlying concepts and principles of a subject and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements.



Evidence of some logical, analytical thinking and some attempts to synthesise, albeit with some weaknesses. Some evidence to support findings/ views, but evidence not consistently interpreted. Some relevant conclusions and recommendations, where relevant

12.6

PRACTICAL APPLICATION SKILLS

Different approaches to solving problems in particular contexts.



Rudimentary application of methods, materials, tools and/or techniques but without consideration and competence. Flawed appreciation of the context of the application.

10.5

TRANSFERABLE SKILLS

Communicate the results of their study/work accurately and reliably, and with structured and coherent arguments; the qualities needed for employment requiring the exercise of some personal responsibility within a structured and managed environment.



Can communicate in a suitable format but with some room for improvement. Work lacks coherence in places and could be better structured.

2.25