UNIVERSITY OF CAPE TOWN

Department of Electrical Engineering

EEE3097S – Electrical and Computer Engineering Design Project Outline 2018

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Teaching Assistant: Mr. Jason Hardy

Inputs from Dr. Simon Winberg

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Contents

1. Introduction

Welcome to the EEE3097S Electrical and Computer Engineering Design course. Students are strongly encouraged to begin the course by reading through this document, since it contains the project description and discusses other important elements of the course. If you find any errors in this document, please notify the Course convenor and the Teaching assistant.

In this course students will be assigned a development project relevant to the Electrical & Computer Engineering discipline within which they will need to design a system and test the system against the technical specifications. This will provide insight to understand the intricacies of the design of systems, which also consists of sub-system design and testing. Students will be expected to approach the development process in a systematic way using principles that was learnt in the EEE3088F course.

The learning outcomes of the EEE3097S course are listed below:

- Knowledge
  - Understanding of the development process where the user requirements need to be identified and refined
  - Awareness and understanding of various design processes
- Skills
  - Identifying and clearly stating the user requirements of the system to be developed
  - Translating the system's user requirement into technical specifications
  - Describing the system using modelling tools such a use case diagrams, sequence diagrams, activity diagrams, class diagrams, block diagrams
  - Identifying multiple approaches to solve specific problems in the project and selecting one approach based on the constraints of the project, sub-system requirements and the performance metrics of the system that need to be optimised.
  - Identifying of all sub-systems needed and stating each sub-system's requirements.
  - Identification of multiple components and the selection of components with reasons. Components are chosen so that the sub-system's technical requirements will be met.
  - Sub-system development consisting of theoretical calculations, simulations, build and test. Ensure that results of tests can be used to either confirm if sub-system requirements are met or not met.
  - Logical and systematic integration of working sub-systems and relating testing to realise the system
  - System level testing, or system acceptance testing, to ensure that the system requirements are met and the user requirements are met.
  - Documenting the system development process in a clear written report for engineering audiences and the community at large
  - Communicating and demonstrating the system and sub-systems using oral methods, such as presentation slides and clear demonstrations, for engineering audiences and the community at large
- Values and Attitude
  - Follow a quality design approach in the system development process: requirements, design, selection of components, theoretical calculations, simulations, build and testing
  - Understand and demonstrate the important of documentation and oral communication
  - Appreciate the need of effective teamwork and project management in system development

A design project is assigned requiring team and individual work equivalent to 8 credits for each team member. Groups will typically have three team members, resulting in a project equivalent to 32 credits or an equivalent of 320 total hours. This accounts for the group work and individual work.

2. Project description

2.1 Introduction

The objective of this project is to develop a Wireless Melody Player that provides the following functionality:

- A user can select a tune on a mobile app.
- The information relating to the selected tune is sent from the mobile device to the transmitting Raspberry Pi (RPI) that encodes and transmits this tune to the receiving Raspberry Pi (RPI) wirelessly using either visible light or infrared light.
- A receiving RPI receives the encoded tune, decodes the message and plays the tune via a speaker in real-time, with minimum delay as possible.

When the user presses a sequence of tunes on the mobile app, a melody can be played. Examples of popular melodies are: “Happy Birthday to you, Happy Birthday to you, …” and “Twinkle Twinkle little star, …”. An illustration of the components of wireless melody player is shown in Figure 1.

A transmitter peripheral must be developed for the transmitting RPI, as well as a receiver peripheral for the receiving RPI. A mobile app must also be developed and should be able to interface with the transmitting RPI.

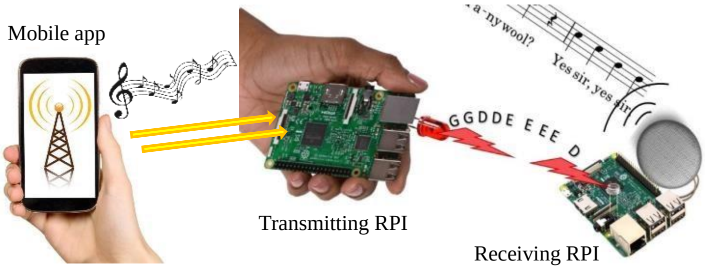


Figure 1: Wireless Melody Player, in use, sending a tune

The electronic components that make up the peripherals may be implemented on a veroboard. Guidelines related to the transmitter and receiver peripherals are described below:

- **Transmitter peripheral**: this is essentially an LED that would either be powered directly from a GPIO port or via a transistor amplifier to increase the current flowing through the LED, so that the emitted light can travel a further distance (see Figure 2).
- **Receiver peripheral**: this peripheral may use a phototransistor (or alternate receiver) together with filtering and amplification circuitry. The speaker can connect to a small amplifier circuit, or audio facilities on-board the RPI can be used. See Figures 3 and 4.

Modulation and demodulation of the data sent between the transmitting RPI and the receiving RPI must also be implemented. This can be done in software. Modulation techniques that can be explored include Amplitude Shift Keying (ASK) and Frequency Shift Keying (FSK). ASK could be simpler to implement and FSK may be less susceptible to interference and fading.

ASK modulation can be implemented by either changing the duty cycle (to make the LED brighter or dimmer) or by incorporating a Digital to Analog Converter (DAC) (or similar circuit) in the design. FSK modulation can be implemented by changing the frequency of the flashing of the LED. In this case, timers or an interrupt driven by a timer would be needed to implement this operation.

The system must be able to characterise the speed of data transfer or the data rate, the bit error rate as a function of distance between the transmitting RPI and the receiving RPI.

2.2 The Tunes

On the mobile app, there should be multiple tunes that can be selected by the user. The tunes will consists\ of beeps of various notes (e.g. A, B, C, etc) at various amplitudes. Additional functionality such as fading, sustain effects on the notes can be added later to make the sounds more pleasing to the ear.

Each tune can be stored as a sequence of byte tuples (X, Y, Z), where X, Y and Z contain 8-bits of data (values from 0 to 255), each read from the transmitting RPI's LED(s). X represents the note to play, Y represents the amplitude of the note, and Z represents the note duration x10 ms. The longest note should be 2550 ms. Consider using interrupts to assist with playing the sounds.

The system may be extended to include duplex communication, in order to facilitate the re-transmission of data when the received data has errors.

Additional functionality: A second channel could be added. For instance, if the system is working with a red LED, a second green LED could be added. Light filters could be added to the photo-transistors to make them sensitive to only one of the LEDs. This way, two channels of data could be produced, to increase the data rate between the transmitting RPI and the receiving RPI.

2.3 Design optimisation criteria

The Wireless Melody Player should be designed so that the following two properties of the system are maximised:

- Speed of data transfer or data rate between the transmitting RPI and the receiving RPI
- The distance between the transmitting RPI and the receiving RPI

2.4 Suggested Circuits

The suggested circuits for the transmitter, receiver and the sound amplifier are shown in Figure 2, Figure 3 and Figure 4 respectively.

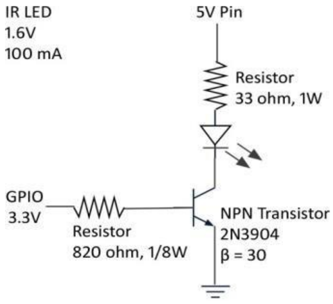


Figure 2: Suggested transmitter circuit (adapted from https://www.raspberrypi.org/forums/viewtopic.php?f=37&t=117580)

The receiver needs to have, at least, a photo-transistor (or some other photo-sensor) and an amplifier. The addition of a band-pass filter, to filter out noise that might get picked up by the flashing of fluorescent tubes, is advisable. The levels (that the circuit is responsive to) may also need to be changeable to compensate for ambient light conditions.

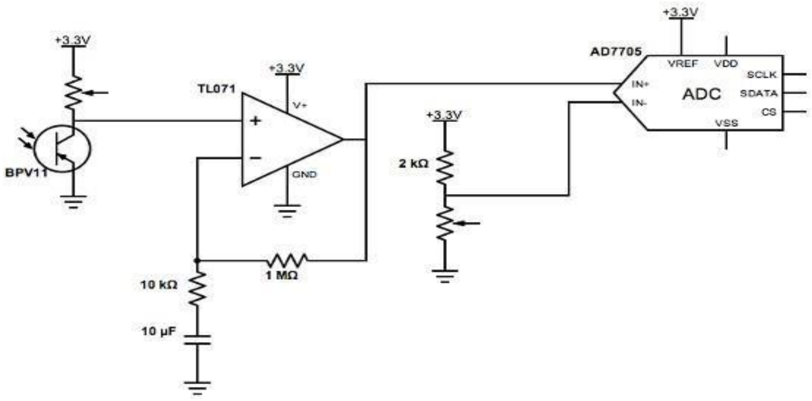


Figure 3: Suggested receiver circuit (based on http://web.eng.gla.ac.uk/RPI/2013/4/)

A simple amplifier circuit using, for example, a transistor or an OpAmp, is shown below. The signal input lines can be connected to the DAC, or to a GPIO pin and the other pin to ground. If not using a DAC, a PWM signal may be used.

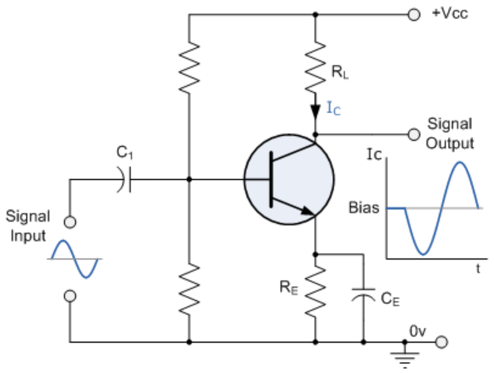


Figure 4: Sound amplifier for connecting to a speaker

2.5 Mobile App

Groups will most likely be building an Android phone application. There is a web application named MIT App Inventor for Android, which allows the user to build an app without doing any coding. **This approach may be used, BUT THE GROUP MARK WILL BE SCALED BY 0.9.** e.g. if your group scores 54% and you used MIT app inventor, the final mark will be scaled as follows: 54% * 0.9 = 48.6%.

https://fossbytes.com/mit-app-inventor-great-way-develop-android-apps-no-coding/

3. Milestones

There are three milestones for the project. The details of the deliverables and the submission date for each milestone is described below:

- Deliverables for milestone 1:
  - **Group Question and Answer session, Friday 10th August 2018**: each group will meet with the course convenor/teaching assistant to answer questions relating to the development process so far and component selection.
  - **Report, Friday 10th August 2018, documenting the following**: identification and refinement of the user requirements, translating the user requirements into a technical system specification. Describing the system using modelling tools such as use case diagrams, sequence diagrams, activity diagrams, class diagrams and block diagrams. Identifying multiple approaches to solve specific challenges in the project and selecting one approach based on the constraints of the project and the performance metrics of the system that need to be optimised. Identification of all sub-systems needed and stating each sub-system requirements. Selection of components based on constraints of the project, sub-system requirements and the performance metrics of the system that need to be optimised.

- Deliverables for milestone 2:
  - **Demonstration, Thursday 30th August 2018**: demonstrate the testing of each sub-system and results of these tests should either confirm that the sub-system's technical specifications were met or not.
  - **Report 2, Friday 31 August 2018, documenting the following**: sub-system development consisting of theoretical calculations, simulations, build and test. Ensure tests are carefully designed to show results to either confirm if the sub-system requirements are met or not. Planning of the the integration of sub-systems detailed test plans.
  - **Subsystems to be independently marked during the demonstration**:
    1. Android/iOS app communicating with RPi – send (any) data to the RPi.
    2. InfraRed Tx and Rx – (any) input to the Tx circuit and response output from Rx circuit (can be simple ON/OFF).
    3. Audio generation – RPi playing user/code generated sound (i.e. not an .mp3 file). This can be checked on hardware described in system 4 below, or on an oscilloscope to remove any dependence on system 4 below.
    4. Audio amplification – speaker hardware generating any sound. Audio Source can be from system 3 above, but also from a bench signal generator in whitelab/Sasol lab to remove ant dependence on system 3 above.

- Deliverables for milestone 3:
  - **Presentation, Thursday 27th September 2018**: oral presentation using powerpoint slides to describe the overall process that was followed in the system development.
  - **Demonstration, Thursday 27th September 2018**: demonstrate the testing of the system and results of these tests should either confirm that the system's technical specifications were met or not
  - **Report, Sunday 30th September 2018, documenting the following**: logical integration of working sub-systems and testing that the integration was successful to realise the system. System level testing to ensure that the system requirements are met and the user requirements are met. Refine work done for milestone 1 and milestone 2 and integrate into report.

If there are any clashes with any of the submission dates, please inform the course convenor and the TA by Monday the 30th of July 2018.

Please be aware of the report templates for each milestone. These can be found on Vula. The report template provides an initial structure of the report as well as tips and guidelines of what is expected in each section. Please pay attention to these guidelines as they will be used to assess the quality of your group's submission.

Demonstrations will take place in the Blue Lab on the scheduled demonstration day. Students can work in the Sasol lab until their time is ready to demo. At least one member of the group needs to be present for the demo.

4. Calculation of the final mark for EEE3097S

The weighting of the milestones for the final mark calculation is summarised in the table below.

Table 1: Summary of the milestone weighting for the EEE3097S course

Assessment Task	**%**
Milestone 1: report	20%
Milestone 1: Q & A on design process and component selection	5%
Milestone 2: report	20%
Milestone 2: sub-system demonstration	5%
Milestone 3: report	20%
Milestone 3: system demonstration	30%
Total	**100 %**

The detailed rubric for each of the report milestones can be found in the report template document on Vula. Please note that there is no final exam for this course.

5. Group number and team members

Each team has been assigned three members. The details of the groups are summarised in Table 2.

Table 2: EEE3097S design groups

Student Name	Student Number	Group Number
Angwenyi, Dancan Matara	ANGDAN002	5
Bell, Andrew Peter	BLLAND009	13
Buckinjohn, Ethan	BCKETH001	1
Chen, Anran	CHNANR001	7
Copley, Matthew James	CPLMAT001	8
De Beer, Samuel Christiaan	DBRSAM003	11
Dhliwayo, Tapuwa	DHLTAP001	4
Eseko, Francis Yusto	ESKFRA001	3
Folly, Yohennas	FLLYOH001	2
Fransch, David Joshua	FRNDAV011	4
Godlonton, Adam	GDLADA001	10
Granelli, Michael Graham	GRNMIC028	9
Guo, Heng Rui	HNGGUO001	4
Hassam, Mahomed Asif Yousuf	HSSMAH005	12
Heald, Dillon Alexander	HLDDIL001	15
Heylen, Muhammad Yusuf	HYLMUH001	1
Hill, Christopher Howard	HLLCHR016	14
Hodgson, Timothy Craig	HDGTIM003	6
Ilsley, Peter Dylan	ILSPET001	12
Joffee, Callum	JFFCAL001	7
Kalogirou, Matteo	KLGMAT001	3
Kaplan, Kelsey Paige	KPLKEL001	11
Katemauswa, Nyashadzaishe	KTMNYA001	9
Khumalo, Ndumiso	KHMNDU005	6
Maluleke, Mapula Cathrine	MLLMAP004	15
Maminimini, Munesu	MMNMUN001	8
Mapana, Tlotliso Paul	MPNTLO002	7
Mazara, Tadiwanashe	MZRTAD001	10
Mckey, David Ciaran Alan	MCKDAV012	11
Mouton, Elle	MTNELL004	2
Murning, Kevin Mark	MRNKEV001	2
Naidoo, Joash Nicholas	NDXJOA004	15
Naidoo, Mahesh Shailendra	NDXMAH010	3
Nyazenga, Tafadzwa	NYZTAF001	5
Pencharz, Jake Jay	PNCJAK001	1
Pohl, Alan Christopher	PHLALA005	12
Schroder, Stefan	SCHSTE054	13
Shklaz, Tamir Yaakov	SHKTAM002	6
Simpson, Senyo Michael	SMPSEN001	13
Singh, Harjot	SNGHAR006	9
Singh, Jehan Rajendra	SNGJEH001	10
Stein, Joshua Eytan	STNJOS005	8
Tumiel, Thomas Joseph	TMLTHO001	5
Van Der Merwe, Max Nikoi	VMRMAX002	14
Wanna, Mcmoses Malima	WNNMCM001	14

Each group needs to assign a group leader, a project manager and a note taker who takes down minutes of team meetings.

The technical tasks of the project must be distributed evenly amongst team members, otherwise the team may lose marks in both the report submissions and the demonstrations.

6. Self-study topics for EEE3097S

There are several self-study topics for the EEE3097S course. It is the student's reponsibility to identify sources of information to learn more about these topics. Students are encouraged to visit the library and search for online resources. An incomplete list of these self-study topics and online resources on these topic are given below:

- Unified Modelling Language (UML)
  - Use case diagrams: https://www.youtube.com/watch?v=zid-MVo7M-E
  - Activity diagram: https://www.youtube.com/watch?v=XFTAIj2N2Lc
  - Sequence diagram: https://www.youtube.com/watch?v=XIQKt5Bs7II
  - Block diagram: https://www.youtube.com/watch?v=5h0uSIDC91Y
  - State transition diagram: https://www.youtube.com/watch?v=OsmWASXE2IM and https://www.youtube.com/watch?v=PF9QcYWIsVE

- Requirements
  - User requirements and system specifications: https://www.youtube.com/watch?v=vpNnZDwC_vs
  - Functional and non-functional requirements: https://www.youtube.com/watch?v=zCX-N1H8Vps
- Embedded coding on the Raspberry Pi
  - Students will learn embedded coding skills on the Raspberry Pi in the EEE3096S Embedded Systems II course.

7. Project constraints

Two of the project constraints are described below:

- Each group has a total budget of R550 for components. This excludes the cost of the Raspberry Pi 3, which students will receive from the EEE3096S course.
- Timeline from start to finish: 10 weeks
- Access to White Lab: until 6pm in the evenings. No 24 hour access.

There are also other project constraints and students are encouraged to identify these during the course.

8. Ordering of components

Ordering of components will be handled by the TA, Mr. Jason Hardy, who will make one large order for the class with Mr. Justin Pead's assistance. If groups purchase their own components, they will not be reimbursed.

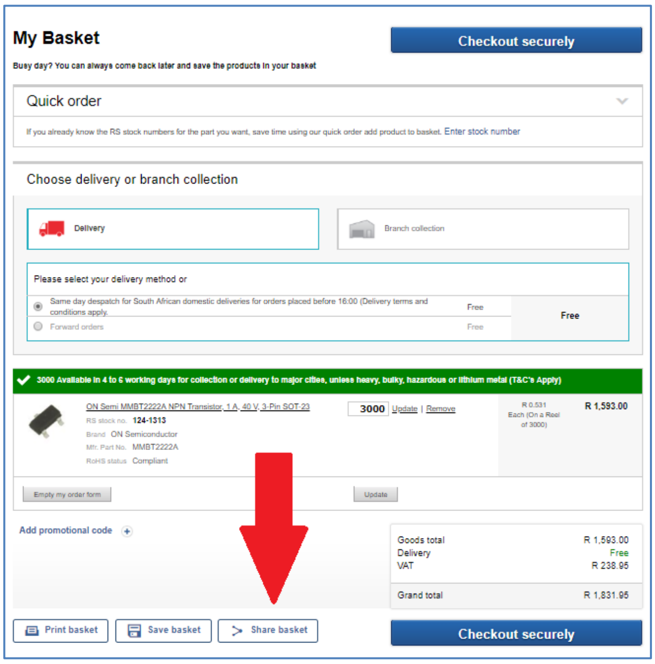
Please see the following link to view what components are available in the While lab: http://whitelab.uct.ac.za/ (item 3 under Useful Linker)

Components not found in the White Lab will be ordered from RS Components. In order to streamline the process, each group must Add all the items they wish to purchase to the RS Components Basket. One person from each group must "share the basket" with the TA. The Share basket button can be found at the bottom page of your basket (see images below). Fill in the form details appropriately, with the "Mail to" field containing the TA's email address, and the Subject containing the course code and group number.

PLEASE SHARE THE BASKET WITH YOURSELF FIRST TO MAKE SURE THAT THERE ARE NO MISTAKES!! Once you are happy, share the basket with the TA.

Things to be mindful of:

- Product availability – there are roughly 3 weeks between milestone 1 and milestone 2. Do not order components which have a lead-time of more than a week. If you do, the chances are high that you will not have enough time to build/test/demonstrate at milestone 2.
- Quantities of units – some components are sold in groups of 10 or 20, or on reels (3000 units). Be careful what you order as this will drastically affect the total price of your basket!
- Your goal should not be to max-out the budget. This will reflect poorly on the group.



My Basket

Busy day? You can always come back later and save the products in your basket

Quick order

If you already know the RS stock numbers for the part you want, save time using our quick order add product to basket. Enter stock number

Choose delivery or branch collection

Please select your delivery method or

● Same day despatch for South African domestic deliveries for orders placed before 16:00 (Delivery terms and conditions apply. Free

○ Forward orders Free

Free

✓ 3000 Available in 4 to 6 working days for collection or delivery to major cities, unless heavy, bulky, hazardous or lithium metal (T&C's Apply)

ON Semi MMBT2222A NPN Transistor, 1 A, 40 V, 3-Pin SOT-23

RS stock no. 124-1313

Brand ON Semiconductor

Mfr. Part No. MMBT2222A

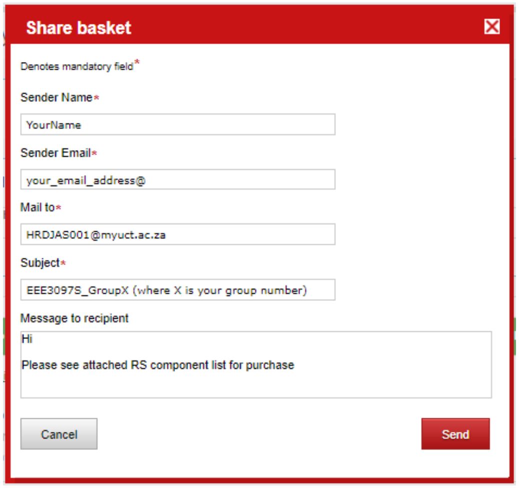
RoHS status Compliant

3000 Update | Remove

R 0.531 Each (On a Reel of 3000)

R 1,593.00

Goods total	R 1,593.00
Delivery	Free
VAT	R 238.95
Grand total	R 1,831.95



Share basket

Denotes mandatory field*

Sender Name*: YourName

Sender Email*: your_email_address@

Mail to*: HRDJAS001@myuct.ac.za

Subject*: EEE3097S_GroupX (where X is your group number)

Message to recipient:

Hi

Please see attached RS component list for purchase

9. DP

DP will be granted to groups that submit reports for all three milestones.

10. Rules

Some rules that all groups should be aware of

- Students may not purchase a fully working transmitter and receiver peripheral. These need to be designed and built as part of the project.
- All reports should be submitted on Vula in .pdf format with filename format suggested in the report template. Do not submit a .zip file or .doc file.
- For demonstrations, at least one member of the group needs to be present. Members who are not present need to have a valid excuse with supporting evidence (i.e. sick note). For team members who are absent from the demonstration without a valid reason, marks will be deducted from their individual demo mark.
- The course convenor may use the team's summary of contribution by each member to distribute marks unequally amongst team members
- No handwritten reports and hand drawn diagrams will be accepted in the report submission
- Code libraries that are used must be done so ethically (must reference properly etc.). Bulk copy-paste of code is prohibited, and if done will be prosecuted. Sample code provided by vendors (e.g. Android Developers) can be modified and used, but should be understood by the user.

11. Penalties

Groups and individual team members should be aware of the following penalties

- Report submission
  - Each day of late submission, translates to a penalty of 5%
  - A penalty of 5% will be deducted for messy and unstructured work
  - For excessively long reports, 5% - 10% will be deducted from the final report mark
- Demonstrations
  - If all team members are absent from the group's demonstration time-slot, the entire group will be given 0% for their demonstration mark
  - Team members who are absent from the demonstration without a valid reason and supporting evidence, will get marks deducted from their individual demonstration mark

If technical work was not spread approximately evenly amongst team members, marks may deducted from all group members. Furthermore, if groups use MIT App Inventor to develop their app, then the final mark will be scaled by a factor of 0.9. See Section 2.5.

12. Lab venue and time-slots for EEE3097S students

The scheduled time in the timetable for EEE3097S students to use the lab facilities is on Thursdays from 14h00 – 16h00. The labs that are assigned to EEE3097S students is both the Sasol Lab and the Blue Lab.

13. Course support

Support for the EEE3097S course is offered by the course convenor, TA and tutors during the following time-slots in the semester

- **Course convenor, Dr. Abdul Gaffar (yunus.abdulgaffar@uct.ac.za)**: Mondays 4pm – 5pm, either during lecture venue (Snape LT2) or Dr. Abdul Gaffar's office (Room 7.10)
- **Teaching assistant, Mr. Jason Hardy (HRDJAS001@myuct.ac.za)**: Thursdays 13h00 – 14h00 in the Sasol Lab or the Blue Lab for general queries, and Thursday 14h00 – 16h00 for technical support in the Sasol Lab or the Blue Lab
- **Tutors**: Thursdays 14h00 – 16h00 for technical support in the Sasol Lab or the Blue Lab

Students may also email the course convenor and the TA with queries. However, expect a response time of approximately 2-3 days.

14. Timeline

A suggested timeline with major events related to the EEE3097S course is summarised in Table 3.

Table 3: Timeline of events for the EEE3097S course

Week number	Lecture details	Milestone details
1	Introductory lecture: 23rd July 2018, 4pm – 5pm in Snape LT 2	
2		
3		Milestone 1: report and Group Q and A session on Friday 10th August 2018
4	Lecture on milestone 2: 13th August 2018, 4pm – 5pm in Snape LT 2	
5		
6		Milestone 2: demonstration on Thursday 30th August 2018 and report due on Friday 31st August 2018
7	Lecture on milestone 3: 3rd September 2018, 4pm – 5pm in Snape LT 2	Milestone 2: groups that did not demonstrate working sub-systems on 30th August 2018 need to demonstrate their sub-systems on Thursday the 6th of September 2018.
8		
9		
10		Milestone 3: demonstration on Thursday 27th September 2018 and report due on 30th September 2018

15. Student responsibilities and course convenor & support staff's responsibilities

It is important to clarify the responsibilities of the students and the course convenor & support staff to prevent misunderstandings and to ensure that learning occurs in an efficient way.

15.1 Student responsibilities

Students are strongly encouraged to take responsibility for their studies. Having a positive attitude and an enquiring mindset are vital to academics and other areas of life as well.

Accepting responsibility for your studies in the EEE3097S course means the following:

- Developing a proactive mindset
  - Starting earlier with tasks and working consistently over the semester. A recipe for disaster is to wait until a day or two before a milestone to only start working towards the deliverables.
  - Focus on aspects that you have control over and spend little to zero energy on things that you cannot control
  - When starting a major activity, begin with the end in mind
  - When you encounter a topic that you need to learn more about, first identify multiple sources of information. This can include resources in the library or online resources. Then, take responsibility to understand this topic in detail.
- Developing a healthy and productive team
  - Have regular face to face meetings where the points of discussions are identified before the meeting.
  - Develop a project plan with goals to achieve before the milestone date. A plan helps provide direction and focus.
  - Assign roles in the team: team leader, project manager and team secretary.
  - Clarify expectations as early as possible. One major source of conflict is not understanding each team member's expectations.
  - First aim to understand the other person's point of view before trying to get your point across. Conflict can be resolved by first listening to each other, echoing what the other person is saying and then putting together plans to either accommodate, compromise or collaborate. Avoidance and withdrawal simply delays when conflict flares up.
  - Respect your team members by encouraging each other, being honest, listening to each other, having a trusting mindset and being empathetic.

- Reading through this project details document in details and understanding all the contents
- If there are large periods of time that you are not on campus or cannot attend demonstrations or not contribute to the technical progress of your team, please inform the course convenor and the TA as well. This shows responsible behaviour.

15.2 Course convenor and support staff responsibilities

Responsibilities of the course convenor and the support staff (TA and tutor)

- State the learning outcomes of the course and ensure that the course assessment is matched to the learning outcomes
- Clarify the project, milestones and the marking rubric for assessments
- State the rules of the projects
- Be available during specific timeslots in the week to handle general queries as well as technical queries. Furthermore, respond to email queries within a 2-3 day period.
- Give feedback on submitted deliverables within 1 week

16. Conclusion

We hope that you enjoy this course and learn design skills that will be beneficial to you in your 4th year EEE4022 project and your career.