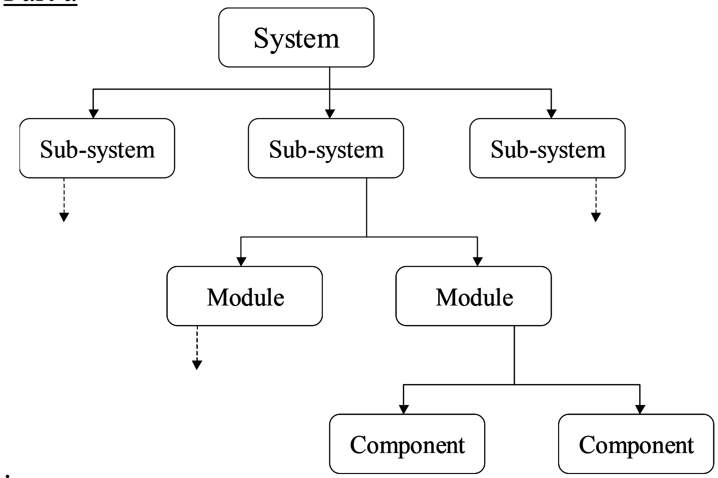
Solutions to EEE115 Spring 2008

Question 1

Part a



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System

System or system specification is the top-level of our hierarchy. At this level the system is described only in a terms of its external behaviour. Details about the internal behaviour of the system are left to the subsequent levels.

Sub-system

Sub-systems represent divisions in the functionality/requirements of the overall system. Often, sub-system definitions directly relate to the system specification statements.

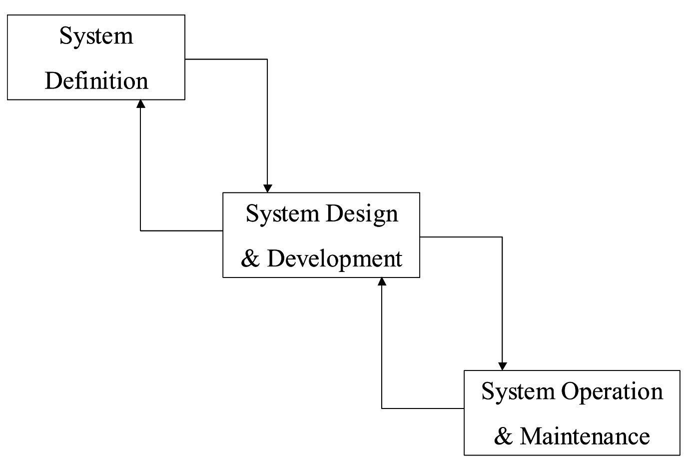
Modules

Modules are high-level functional blocks required to construct a sub-system.

Component

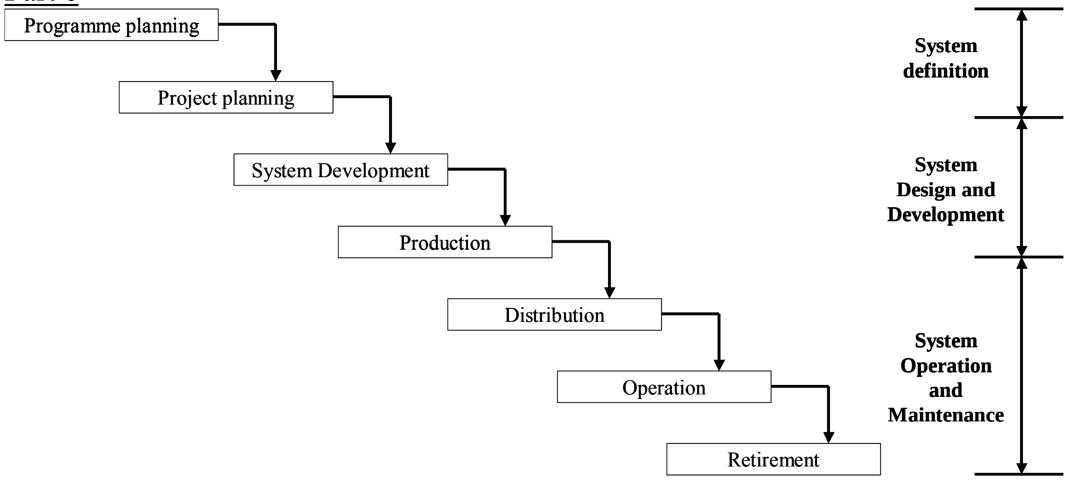
Components are the lowest level building blocks for the system. Electronic components and programming language functions fall into this category.

Part b



3 phase systems engineering life cycle

Part c



1.Programme planning

Fundamentally the requirements capture phase, but results in the identification of actions and projects to support the development of the whole system. A specification of requirements for the whole system is produced along with associated programmes of work.

2.Project planning

Determination of suitable specifications for the identified projects together with a work programme and plan of action.

3.System development

This stage further refines the project plan specifications into detailed specifications, drawings and bills of materials for the manufacturer.

4.Production

Actual realisation of the system from specification (from section 3) to reality. Can involve a variety of techniques depending on the system. For example, the development of hardware or software for an electrical system to building of a warehouse for a factory.

5.Deployment

Delivering the system (product or services) to the user (or customer).

6.Operation

The system is in full service. This phase also includes activities such as maintenance and updating.

7.Retirement

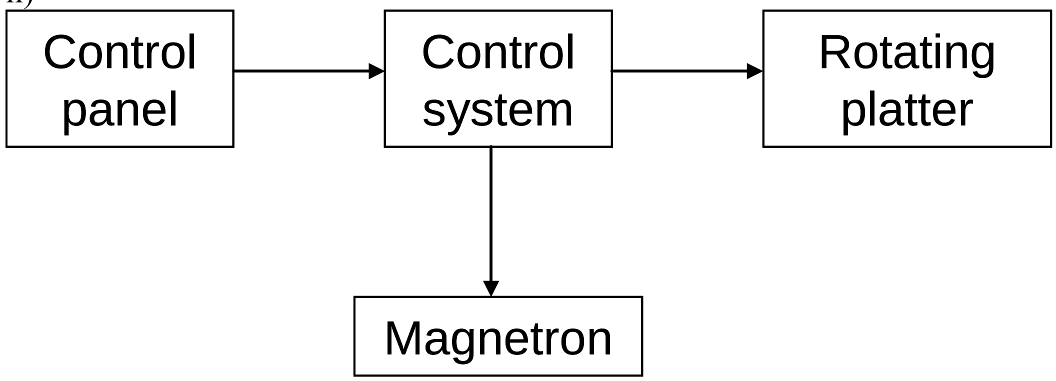
After a period of operation the system is phased-out and possibly replaced by a new system.

Part d

i) components of a microwave oven:

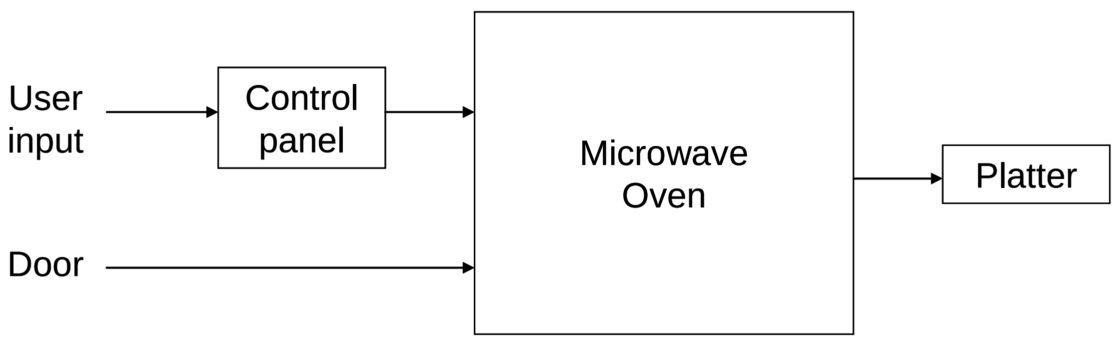
Magnetron (the microwave emitter), protective enclosure, control panel (human input), control system/timer, rotating platter (turn table), power supply, door, safety system

ii)



iii)

As user guide writer I would partition according to function and input output connections. For example, cooking features such as defrost and power rating and the timer all of which are accessed through the control panel.

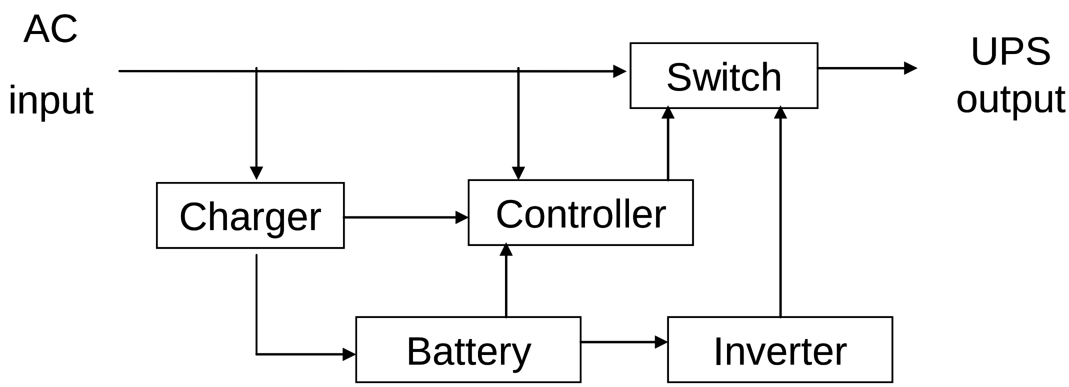


Part e

Abstraction is the process of filtering out certain details about a system (sub-system or element) to obtain a more generic description of the system's behaviour. This means an engineer can benefit by transferring knowledge gained in analysing one system to other similar systems even though their final usage may be completely different.

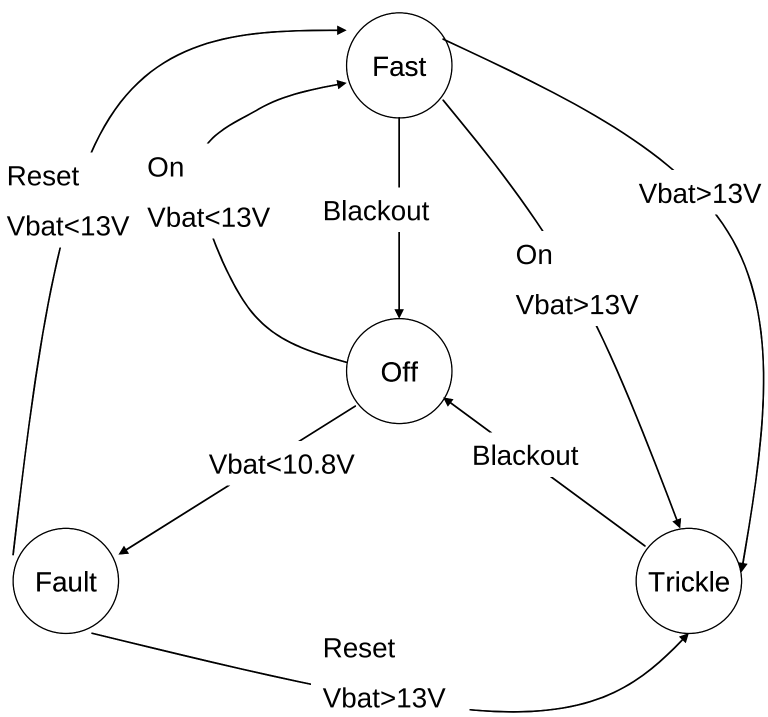
Question 2

Part a



<u>Part b</u>
Input power = output power + lost power and efficiency = output power/input power
The maximum output power is 240VRMS * 13A = 3120W
About 10% of this is lost due to inefficiencies thus
Input power to the inverter = output power /0.9 =3446W
Input voltage to the inverter is nominally 12V therefore a current of 3446/12=287A is required.
Therefore for 2 hours of operation the battery capacity should be 575Ah or greater.

<u>Part c</u>



Part d

Pseudo-code

```
While 1==1
        If mains not present
                Set alarm
        End

        Vbat=ReadADC          // read the battery voltage
        If Vbat<10.8
                Shutdown inverter
        End
End
```

Question 3

Part a

Modelling is important in all branches of science and engineering because it allows one to make predictions about the behaviour of a system. One can use these predicts to design/choose certain parameters for the model to see if a certain response can be matched. This is often quicker, and cheaper than making a prototype. In essence one is abstracting the behaviour of the system from the real world to the mathematical or numerical world. Thus, the designer can explore many solutions without actually having to build any circuitry. Obviously, predictions are only as accurate as the model used permits. Models are also used to generate test data from which the performance of a real world system can be assessed.

Part b

Transfer functions are mathematical expressions that relate the output response of a system to its input in the form of a fraction. They are useful because transfer function for many subsystems cascaded together can simply be multiplied together to obtain an overall transfer function. The proviso being that each individual subsystem does not excessively load the proceeding one such that it alters behaviour.

Part c

A system is said to be linear if its response to the sum of two input signals can be obtained by considering each signal separately and summing the response. What this means is that for linear systems, if you know the response of the system to a single input you can develop the response for any number of combined inputs.

Linear system $y=kx$

If for two inputs x_1 and x_2 the output will be $y=k(x_1+x_2)=kx_1+kx_2$

Nonlinear system $y=x^2$

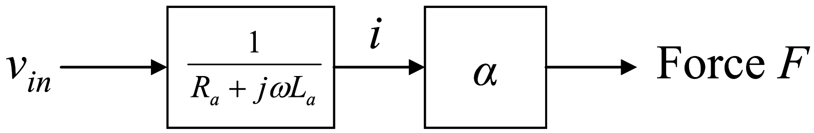
For the combined input $y=(x_1+x_2)^2$ for individual input $y=x_1^2+x_2^2$

Part d

$$i = \frac{v_{in}}{R_a + j\omega L_a}$$

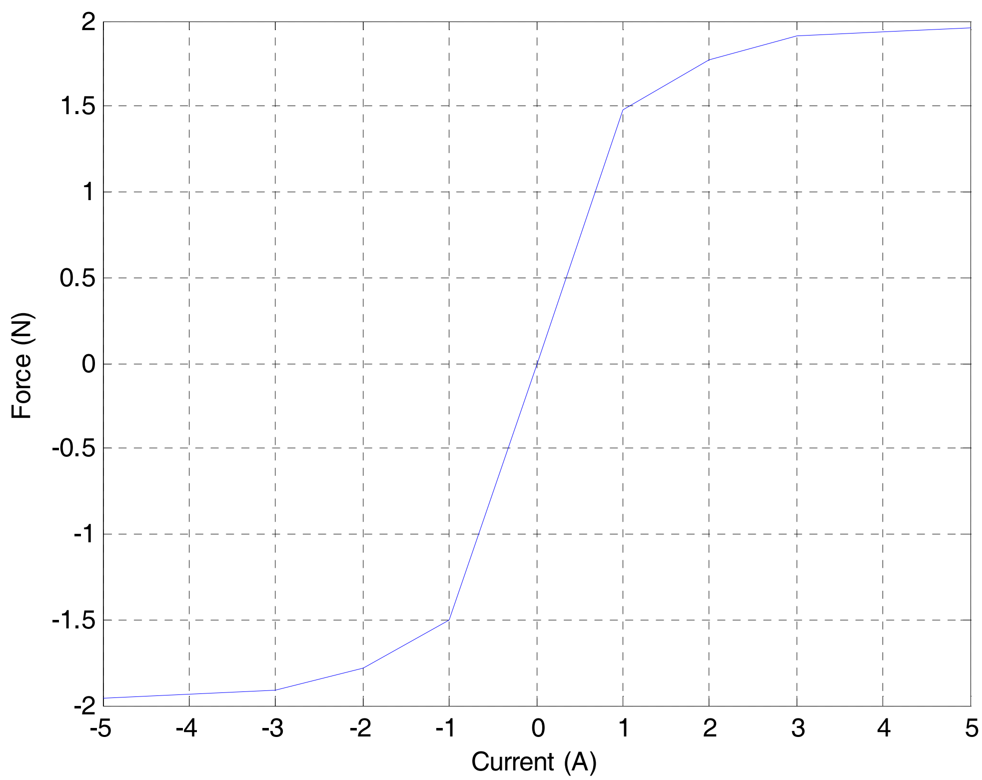
Transfer function is $\dfrac{i}{v_{in}} = \dfrac{1}{R_a + j\omega L_a}$

Part e



Part f

You can do this by inspecting the data or by plotting a graph of F v's i. Either way you can see that the response is approximately linear between -1A and 1A. Beyond this value the a large change in current is need for only a small change in force. Therefore, -1A and 1A should be chosen to be the limits of our linearised model. To linearise the response you can fit a straight line to the -1A to 1A response or inspect the table.



Inspecting the graph one can see Δx=2 and Δy=3, therefore the gain can be approximated the gradient.

α_{linear}=Δy/Δx=1.5N/A

<u>Question 4</u>

<u>Part a</u>

Considered operating time is T hours

There are F_{n-s} non-serious failures with a down time of D_{n-s} for each failure

There are F_s non-serious failures with a down time of D_s for each failure

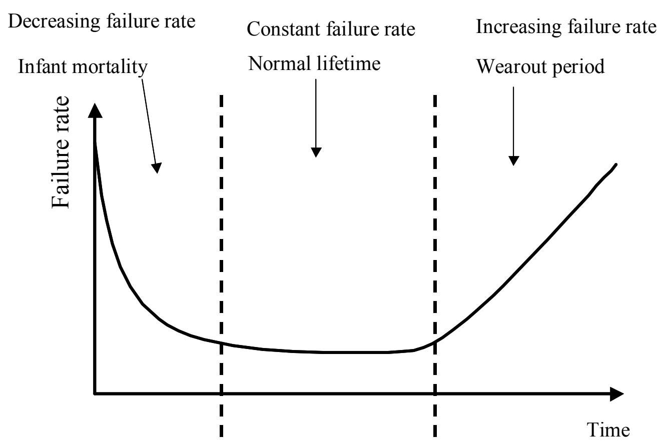
Total down time due to failures is $F_{n-s}D_{n-s} + F_sD_s$

System running time is $T-(F_{n-s}D_{n-s} + F_sD_s)$

Therefore the failure rate is $\lambda = \dfrac{F_{n-s} + F_s}{T - F_{n-s}D_{n-s} - F_sD_s}$

Inserting the numbers λ=8.0370e-004 failures/hour

<u>Part b</u>



When systems are manufactured and released on sale they often exhibit a failure rate distribution similar in shape to the bath tub curve. The bath tub curve is divided into 3 sections:

1) Infant mortality – when a system/product is first built a number of these often fail. This can be due to defective components or problems that have arisen during manufacturing. When releasing a product one must ensure that one's customers do not buy products that suffer a high mortality rate.
2) Normal lifetime – this is where the product failure rate has reached a constant level. This is the normal operating time of a product.
3) Wearout period – as the product ages components being to wear, placing an excessive burden on other parts of the system. Eventually a component will fail, possibly resulting in complete product failure.

The exponential equation can be used during the constant failure rate section.

<u>Part c</u>

It has been shown experimentally that a component's lifetime is reduced the closer it operates to its maximum ratings. The reason for this is that many failure mechanisms have a failure rate proportional to Arrhenius equation, $e^{-\frac{Ea}{kT}}$, that is used to describe many processes that occur is chemistry and physics. The Arrhenius equation states that a reaction rate is proportional to an activation energy *Ea*, some physical constant *k* (such as Boltzmann's constant = 8.62×10^{-5} eVK^{-1}) and absolute temperature *T*.

Component manufacturers provide the designer with all manner of design data relating to their components. For example, a transistor datasheet provides information above maximum current, voltage and power dissipation rating. If these ratings are exceeded during operation then it is more likely that the component will fail.
Designers can take advantage of this phenomenon and de-rate their components to achieve greater reliability. They do this by operating component at lower voltage, current and temperature levels.

<u>Part d</u>
Reliability of each system
RA =0.8187
RB =0.6703
RC =0.1353
RD =0.5134
RE =0.3679

Parallel systems
RP1=RB||RC=0.7149
RP2 =RD||RE=0.6924
Rtot =RA*RP1*RP2=0.4053

<u>Part e</u>
Combine RP1 and RP2 to make RS=0.4950
Now there is a new parallel system RP3=RS||RF=0.4950+0.5050*RF
Now Rtot=RA*(0.4950+0.5050*RF)=0.5=0.4053+0.4134*RF
Rearranging give RF=(0.5-0.4053)/0.4134=0.2291

MTBF_F=-2000/ln(0.2291)= 1357 hours.