CANDIDATE GUIDE

DEFINE, INVESTIGATE AND ANALYSE COMPLEX ENGINEERING PROBLEMS

OUTCOME 1

TABLE OF CONTENTS PAGE NO.

CANDIDATE INFORMATION

Details	Please Complete details
Name of candidate	
Name of supervisor	
Work Unit	
Name of mentor	
Date started	
Date of completion & Assessment	

COMPETENCY STANDARD REQUIREMENTS

(Direct extract from SAIMechE's Standard of Professional Competency)

LEARNING OUTCOME 1

Define, investigate and analyse complex engineering problems.

Assessment Criteria:

The candidate is expected to perform a creative, systematic analysis of problems typified by the following performances:

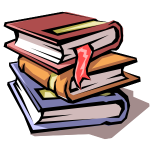
1. Identifies and formulates problem, leading to an agreed definition of the problem to be addressed
2. Collects, organises, and evaluates information
3. Uses conceptualisation, abstraction, modeling
4. Makes and justifies assumptions
5. Uses of analytical methods both mathematical and non-mathematical
6. Evaluates result of analysis, using judgment
7. Expresses understanding emerging from analysis

Range Statement:

The problem may be a design requirement, an applied research and development requirement or a problematic situation in an existing component, system or process. This outcome is concerned with the understanding and judgment of a problem: Outcome 2 is concerned with the solution.

KEYS TO ICONS

The following icons are used throughout the study guide to indicate specific functions:

	**DON'T FORGET/NOTE** **This icon indicates information of particular importance**
	**CANDIDATE GUIDE** **This refers to the learning material in this module which is aligned to the SAIMechE's Competency Standard**
	**EXERCISES** **Practical activities to do, either individually or in syndicate groups during the training process**
	**BOOKS AND WEBSITES** **Additional resource information for further reading and reference**
	**SELF TEST QUESTIONS** **Self-evaluation for candidates to test understanding of the learning material**
	**QUOTATIONS** **Quotations which offer interesting points of view and statements of wisdom and insight**
	**YOUR NOTE PAD** **Provided for candidate to document notes during presentation of training**

GENERAL GUIDELINES

PURPOSE

This module provides easy-to-follow steps to help you to define, investigate and analyse complex engineering problems which are really the basis of the activities of the Engineer. These follow the items listed in section 1 above.

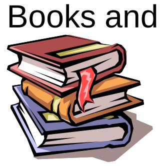
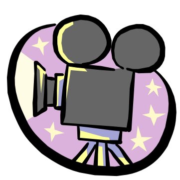
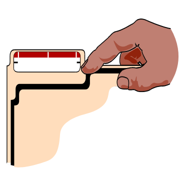
The purpose of the module is to introduce to the Engineer a practical methodology for meeting the requirements of the assessment criteria to comply with Outcome 1.

The approach to this module is by no means restricted to these guidelines only, and the Candidate is expected to research any appropriate references, literature and practices that can support the essence of this competency outcome.

LEARNING OUTCOMES AND RANGE OF LEARNING

This programme uses the basic structure of SAIMechE's Competency Standard and specifically the assessment criteria to take you through the process of learning, as an understanding of the assessment criteria and the depth of understanding required is fundamental to professional competence.

CANDIDATE SUPPORT

Resources	Candidate Guide 	The Candidate Guide is a manual covering the theory on the comprehension and development of advanced knowledge and provides guidance on practical exercises to meet the requirements of the assessment criteria
	Candidate Portfolio of Evidence Guide	This is a separate document which provides guidelines for Candidates on how to compile their portfolio of evidence, and a template to structure their practical task evidence into a file format for assessment by the mentor
	Books and websites 	Refer to references at the end of the Candidate Guide
	Videos 	Refers to any videos that are regarded as relevant to the subject
	Folder enclosures 	This includes all handouts, checklists, etc. e.g. "The Engineer's Code of Conduct"

SECTION 1

DEFINE, INVESTIGATE AND ANALYSE COMPLEX ENGINEERING PROBLEMS

LEARNING OUTCOMES:

- Define and describe what is meant by the word, "engineering"
- Understand the concept of complex engineering problems
- Be aware of the need to define, investigate and analyse these problems

1.1 What is a practical definition of a complex problem?

1. The first question to ask is: Is the problem an engineering one? Does it require an in-depth fundamental engineering knowledge of a specialized nature? Could it be a logistical or project management problem and thus fall outside the need for fundamental engineering knowledge and experience?
2. The second question is to ask what the nature of the problem is. Is it ill-posed, under-specified or even over-specified? Does it consist of a number of dependencies or sub-problems?
3. The third question is to ask whether it is a familiar or infrequently encountered problem.
4. Finally, can the problem be defined in a way that enables one to make progress in solving it?
5. In summary: The right answers arise by asking the right questions at the analysis stage.

1.2 The essential features of complex engineering problems.

A simple, short definition has been constructed that contains the essential elements that are common to complex engineering problems:

"Composed of many ***inter-related conditions***; requiring ***first principle empirical judgment*** to create a solution within a set of ***originally undefined circumstances***"

1.3 The common components of a complex engineering problem

All complex engineering problems will display most of the attributes below. The candidate should interrogate the problem to determine which of these attributes is evident. Should the majority of them prevail, then the problem is indeed a complex one.

1. Evidence of fault or malfunction
2. Inability to meet intended purpose
3. Instability in operation
4. Evidence of unexpected system decline – increase in system entropy
5. Apparent unrelated factors
6. Solution not readily apparent
7. Symptoms mask root cause
8. Requires diagnosis
9. Requires testing
10. Requires research

1.4 The need for methodology

Complex engineering problems lend themselves to a logical process of analysis. Various methodologies exist that can be used as a basis of analysis and formulating the problem definition and relevant components.

1. Clarify the problem so that it is understood. Do not confuse the objective with the problem definition.
2. Where there are unknowns, formulate questions
3. Gather data and information systematically
4. Collate and organise the data

5. Condense and summarise the evidence
6. Break down into smaller discrete parts where possible
7. Brainstorm, apply lateral thinking
8. Review the problem definition identified at stage 1
9. Decide when to proceed with synthesis for possible solutions which would be undertaken using the guidelines in Outcome 2

1.5 Key concepts

Below are some items to consider. Beware of being "trapped" in a traditional intuitive or instinctive mindset that might appear rational, but lacks the structured thinking processes that are required for good problem analysis. By intuitive and instinctive mindset we refer to the common habit of "jumping to a conclusion" on the reasons for the problem before allowing a more structured evaluation process.

In this mindset a solution is also derived which is frequently invalid. Life offers many instances of this "badly assumptive" process; it is usually influenced by the psychological need for display of ego or authority. The comment often made in jest - "*I have made up my mind, do not confuse me with facts*" - while comic, often describes the reality.

Consider the following thought-patterns and methodologies that can either open or close the mind to a process of lateral thinking:

Daydreaming really is the key to solving complex problems, a new study has found.

Some of the most important scientific breakthroughs ever made - by everyone from Einstein to Newton - came about as the geniuses behind them allowed their minds to wander.

Now research by modern day scientists has shown that mere mortals can also improve their problem-solving ability in the same way.

The study showed that people who returned to a difficult task after taking a break and doing an easy task boosted their performance by around 40 per cent.

But there was little or no improvement for people who did another demanding task during the break, used it to rest or did not have a break at all.

Problem solving is puzzle solving. Each smaller problem is a smaller piece of the puzzle to find and solve.

Putting the pieces of the puzzle together involves understanding the relevant parts of the system. Once all the key pieces are found and understood, the puzzle as a whole "snaps" together, sometimes in a final flash of insight.

If your problem solving process doesn't fit the problem at hand, you can execute the process to the highest quality possible and still not solve the problem. ***This is the reason most people fail to solve difficult problems.*** *They're using an inappropriate approach without realizing it. The process doesn't fit the problem.*

As a result [of taking an instinctive, intuitive approach] we unwittingly, repeatedly, and habitually commit a variety of ***analytic sins.*** *For example:*

We commonly ***begin*** *our analysis of a problem by formulating our conclusions; we thus start at what should be the* ***end*** *of the analytic process.*

Our analysis usually focuses on ***the solution we intuitively favour****; we therefore give inadequate attention to alternative solutions.*

Not surprisingly, the solution we intuitively favour is, more often than not, the first one that seems satisfactory. Economists call this phenomenon ***satisficing*** *(a merging of satisfy and suffice). Herbert Simon coined the neologism in 1955, referring to the observation that managers most of the time settle for a satisfactory solution that suffices for the time being rather than pursue the optimum solution that a 'rational model' would likely yield.*

We tend to confuse ***'discussing/thinking hard'*** *about a problem with* ***'analyzing'*** *it, when in fact the two activities are not at all the same. Discussing and thinking hard can be like pedalling an exercise bike: they expend lots of energy and sweat but go nowhere.*

Like the traveller who is so distracted by the surroundings that he loses his way, we focus on the ***substance*** *(evidence, arguments, and conclusions) and not on the* ***process*** *of our analysis. We aren't interested in the process and don't really understand it.*

Most people are functionally illiterate when it comes to structuring their problems. When asked how they structured their analysis of a particular problem, most haven't the vaguest notion what the questioner is talking about. The word ***structuring*** *is simply not a part of their analytic vocabulary.*

Morgan Jones

In its brief 20-year history, Goldratt's Theory of Constraints (TOC) methodology has evolved into a systems methodology that links elements of both soft and hard systems methods. The major component of TOC that underpins all the other parts of the methodology is the TOC Thinking Processes, a suite of logic trees that provides a roadmap for change. They guide the user through the decision making process of problem structuring, problem identification, solution building, identification of barriers to be overcome, and implementation of the solution. Tree-builders make recourse to a set of logic rules, which provide the analytical rigour usually associated with hard scientific approaches. This is combined with the ability to capture softer information and complexity provided by soft OR approaches.

These tools are logical "thinking tools" (known as a group as the Theory of Constraints (TOC) Thinking Processes). They can be used in standalone situations, or together they form a coherent problem-solving and change management system. Their generic purpose is to translate intuition to a format that can be discussed rationally, questioned without offense, and modified to more fully reflect the understanding of the situation. They are used for the construction of common sense solutions to problems as well as to facilitate communication, collaboration, and consensus among those that must be involved in its resolution.

There is also another body of knowledge with a set of tools that are used for problem solving known as TRIZ.

Problems are related to dilemmas, doubts, and decisions. From a "scientific" viewpoint, any problem can be stated in terms of a conflict or conflicts between what are perceived to be necessary conditions of the system that's involved. TRIZ, for example, recognizes this in the way which it deals with conflicts between physical or technical aspects between design requirements encountered in the "invention" process.

A popular and effective tool is the Kepner Tregoe model. The Kepner Tregoe decision making model is a structured methodology for gathering information and prioritizing and evaluating it.

1.6 Understanding cause and effect

Problem identification and definition regularly omits to take into consideration the difference between symptom and root cause. The pressure to create a solution provides the ideal circumstance to confuse these.

The process of constructing a current reality tree from identification of various symptoms will logically assist to identify the root cause. This process enables the links to be constructed, and to show that eliminating a symptom will not remove the root cause of the problem. These are regularly confused and enormous cost is incurred when this error is made as the solution is invalid. Constructing a current reality tree can be regarded as a fun exercise as it challenges the mind to create the necessary links between the observations listed. It is done as free-handed exercise on paper and is more difficult than initially meets the eye. Providing a group of persons with the same list of observations and requesting them to construct a tree will regularly produce very different results. This in itself should indicate that analysis of a complex problem is not simple.

Engineers should be encouraged to study, understand and apply correlation mathematics. Numerous studies have shown that unless the relationship exhibits high levels of correlation, it is unlikely that the relationship exists. Accordingly it is frequent that a solution is proposed that is completely incorrect.

We must emphasize that intuition and instinct regularly impede the logic of these structured types of approach. Thinking is a human behavior and hence subject to the variables and uncertainties of such behavior.

1.7 The necessity for empirical thinking

Complex engineering problems are often resolved (Outcome 2) by applying codes and standards to the design function. Assuming that all the entry data in the formulae, algorithms and programmes used is correct, the “right” result will emerge.

However, numerous cases have occurred where the result has been significantly incorrect, and the designer has failed to notice or appreciate the extent of the error that may have been caused by, for example, the wrong assumption.

It is thus essential that the designer can apply an empirical analysis to the problem. Essentially that is the basis of the tertiary qualification of the Engineer: being able to go back to first principles, apply these to the design methodology and evaluate the result against the computed solution.

Whilst this applies to the solution process in Outcome 2, the same need for empirical evaluation of the assumptions, derived causal links and analytical results remains.

Empirical thinking is clearly assisted by experience with the practical circumstances of analyzing the problem, and this supports the process of gaining experience and demonstrating competence on this programme by being active in the appropriate workplace environment.

1.8 The domain of engineering problems

Engineers will experience complex engineering problems in virtually all life circumstances: they are not confined to the design office, factory or production line. Society embraces engineering across most social and environmental applications. There can be very few modern facilities in the life of a citizen that do not require the professional support of complex problem solving.

It thus behoves the Engineer to accomplish a sound competence in complex problem analysis followed by competence in problem resolution.

Engineers should develop an ability to address any problem that arises, whether or not in the strict domain of engineering circumstances, with methodologies of their choice to progressively provide the practice until it becomes second nature to apply them.

1.9 Uses of codes and standards

Engineers are increasingly making use of codes and standards for design functions, and as mentioned in the item above on “The necessity for empirical thinking”, it is necessary to take time to study the basis of any codes used, the background, revisions, assumptions, limitations etc.

References to codes on the same subject, but from another source, are also recommended to compare code elements.

For this exercise, access the codes issued typically by SANS, BS, ASME, DIN, ISO.

1.10 Assessing ability to solve complex engineering problems

Engineers need to utilise peer and expert source input in addressing complex engineering problems. Be encouraged to assemble a brain-storming group where possible, and invite the opinions of experts and those with experience in the cases being considered. Many minds addressing a problem will normally result in better analysis as long as the process is facilitated. Group problem solving must be facilitated otherwise it can be no more than a discussion session with no defined objective.

1.11 Impact of engineering problem analysis

The various unsatisfactory consequences of complex engineering problem analysis are legendary. A question we can ask ourselves here is, are bridges, for example, designed to stand up or designed not to fall down? The implications for the Engineer here should shift the mind to the essence of life cycle analysis. Many engineering problems result from neglecting to address such life cycle requirements at analysis stage.

This is often evident when the interest in the asset has passed from the designer and constructor to the operator. Can this be influenced at the design and specification stage? Has the analysis gone far enough into the life of the engineering problem being addressed, thus influencing the performance of the engineering solution over the life of the solution? For example, has maintainability been analysed at the conceptual stage? Have environmental issues been taken into account?

Engineering applications are always subject to the feature of "connectedness". This is manifest in systems and an occurrence in one area will inevitably have impact in many other areas. Systems therefore lend themselves to the need for the "what if" type of analysis, where in engineering disciplines the Failure Mode Effect Analysis (FMEA) is used. Since the early adoption of the FMEA process which was developed in the 1950s to assess the reliability of military equipment, the *criticality analysis* was added to chart the probability of failure modes against the severity of their consequences, thus termed FMECA which is being more commonly adopted in engineering analysis.

One of the things that make continuous improvement efforts frustrating is what often seems to be a constant stream of similar problems. Strong problem solving skills are essential to successful continuous improvement activities. Without these skills one is doomed to solving the same problems repeatedly. At analysis stage, a failure mode analysis using one of the fault tree methods is essential. There is a lot of material on this topic in the public domain and the candidate is recommended to research this on an on-going basis.

GROUP DISCUSSION

Select a topic from those listed below:

1. All that engineering is about, is problem solving. Do you agree with this statement? Justify your position.
2. Discuss the meaning of the following words: “rational”, “intuitive” and “assumptions”.
3. Does having a methodology make problem solving more effective? If so, why?
4. What do you understand by the term “root cause analysis” and its role in engineering practice?
5. Are the techniques and methodologies of engineering problem solving limited to the domain of engineering work? Justify your position.

INITIAL TEST

Complete the Initial Test in Appendix 1 (10 minutes are allocated for this).

SECTION 2

PRACTICAL DECISION MAKING MODEL

LEARNING OUTCOMES:

- Understand the practical steps to be taken when defining, investigating and analysing complex engineering problems
- Be competent in using the steps to define, investigate and analyse complex engineering problems
- Be prepared to apply this process in the workplace on a regular and routine basis

2.1 Steps in defining, investigating and analysing complex engineering problems

The Candidate should have reviewed the contents of Section 1 before proceeding to carry out the steps in this section.

Note that each of these steps is aligned with the respective assessment criterion. In this way the Candidate can focus on the essence of the applicable criterion as the steps are undertaken. Start developing the content of the Portfolio of Evidence (POE) with these steps.

The assessment steps:

STEP 1: Identify and formulate problem, leading to an agreed definition of the problem to be addressed

STEP 2: Collect, organize and evaluate information

STEP 3: Use conceptualisation, abstraction, and modeling

STEP 4: Make and justify assumptions

STEP 5: Use analytical methods, both mathematical and non-mathematical

STEP 6: Evaluate result of analysis, using judgment

STEP 7: Express understanding emerging from analysis

STEP 1: Identify and formulate a problem, leading to an agreed definition of the problem to be addressed.

Does the problem have some or all of the following characteristics?

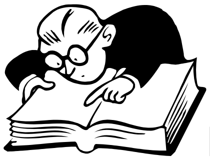
1. *Scope* may encompass entire complex engineering systems or complex subsystems
2. A context that is complex and varying, is multidisciplinary, requires teamwork

3. Would require diverse and significant resources including people, money, equipment, materials, technologies
4. Significant interactions exist between wide- ranging or conflicting technical, engineering or other issues
5. Is constrained by time, finance, infrastructure, resources, facilities, standards & codes, legislation
6. Has significant risks and consequences in a range of contexts
7. The solution is not obvious
8. Solution cannot be obtained with codes or standards
9. Is ill-posed and is over- or under-specified, requiring evaluation and refinement
10. Is not a common occurrence
11. Requires in-depth fundamental and specialized engineering knowledge

The problem exists in the domain of: design; planning; investigation and problem resolution; improvement of materials, components, systems or processes; implementation, manufacture or construction; engineering operations; maintenance; project management; research, development and commercialisation.

It then becomes necessary to state the problem clearly. Poor problem definition is all too common.

Because the capacity of the human mind for formulating and solving complex problems is far too small to meet the requirements for full rationality, individuals often operate within the confines of bounded rationality. They construct simplified models that extract the essential features from the problems without capturing all of their complexity. Individuals can then behave rationally within the limits of the simpler model.



Exercise/ Topic for group discussion

(These exercises/topics for group discussion can be done outside the workshop, as the time allocated will not allow for their completion at the workshop.)

The Candidate is required to seek out an issue in the workplace that can be considered a problem. In order for it to be categorized as a complex problem, it needs to be evaluated using the criteria listed above.

Presentation: For a selected problem, identify which of the above items describe the problem. Can it be categorized as a complex problem? If so, then state the problem clearly bearing in mind its alignment with the above attributes.

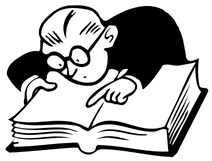
STEP 2: Collect, organize and evaluate information

The challenge now is to assemble the information that describes the problem. This should be categorised into types of information available. There will be known and discrete facts derived from available evidence. Some information may be uncertain or unclear. Some may exist as a result of assumptions.

Doing justice to this process requires returning to the scene of the action in the same way that a detective would gather evidence. Complex engineering problems will most often occur where the circumstances can be visited and interrogated. Avoid the compulsion to jump to conclusions or solutions at this point. It is only to gather the information. Is it a case where pictorial evidence or performance metrics should be obtained?

Collect the information, then organize it into categories of certainty/reliability in list form.
It can then be evaluated with any qualifications or assumptions. List all assumptions. Identify the information that still needs to be identified or validated and describe how it is to be obtained.

Data, information, records, and any evidence should at this point only be in free-body listed form with no structure or configuration.



Exercise/ Topic for discussion

The Candidate is required to provide a record of having carried out the above process for a selected problem. It is recommended that this be done for the problem selected in Step 1.

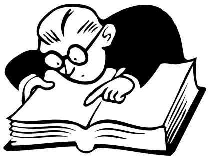
STEP 3: Use conceptualisation, abstraction, and modeling

An abstract can be defined as “an idea or term considered apart from some material basis or object.” We mentioned in Section 1, item 1.5 (Key Concepts) the power of lateral thinking or even day-dreaming. It allows us to think beyond the reality of the problem being evaluated for possible options that do not appear to be connected. This approach can assist in providing leads to overcome uncertainties and hidden aspects of the problem. The result of this process can provide the need for assumptions that inevitably have to be made.

It is at this point in the process of analysis that the Candidate can apply any abstracts or concepts that may assist in filling in the information gaps. Modelling with decision trees can be done, identifying the linkages of the symptoms to each other and the possible root cause.

There are a variety of options that provide modelling assistance. Brain mapping, current reality trees, and other proprietary systems such as Keptner Tregoe are valuable tools to assist the candidate in assembling the information evidence. The ultimate objective is to identify the root cause of the problem. This is more often easier said than done and the tendency to jump to intuitive conclusions must be avoided.

Most significant decisions are made by judgment, rather than by a defined prescriptive model. People are usually content to find an acceptable or reasonable solution to their problem rather than an optimal one.



Exercise/ Topic for discussion

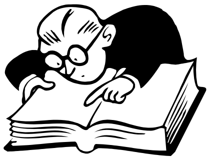
The Candidate is required to provide a record of having carried out the above process for a selected problem. It is recommended to provide a connection between these steps for the problem selected in Steps 1 and 2 above. The candidate should include in the evidence a methodology that has been followed in creating the analytical picture. This will require the candidate to do some research on the available analytical support systems being used in the engineering domain. Commentary on this research is to be included.

STEP 4: Make and justify assumptions

In step 3, the candidate will have made assumptions that are inevitably required to provide the analysis with options to fill in gaps. The comment that "any analysis that requires the fewest assumptions will be the most accurate" is a truism to follow. Where assumptions are made these have to be validated at some point.

> **If we do not stop to question our assumptions, we might make mistakes. Sometimes they can be repaired. Sometimes not.** *Anon*

The Candidate must list all assumptions with any qualifications that apply to them. These must include any envisaged methods of testing them once the final analysis has been constructed.



Exercise/ Topic for discussion

The Candidate is required to show a list of assumptions made in the preceding steps, showing the qualifications applicable to them and the envisaged testing and validation that will need to be made at the solution selection stage. Illustrate where assumptions that may have been made actually turn out to be invalid and how these affected the process.

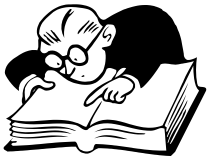
GROUP DISCUSSION

Select one or more of the exercises/ topics for discussion mentioned above, for group discussion.

STEP 5: Use analytical methods both mathematical and non-mathematical

In this step we refer to the use of established engineering discipline-based analysis tools. For mechanical engineering applications there are numerical, mathematical, scientific techniques available which have been the basis of the tertiary engineering degree. Typically these would include stress analysis, thermodynamic, fluid mechanics, dynamics, finite element analysis and numerical methods. These are examples of the tools used by Mechanical Engineers for addressing the analysis of the problems identified in their workplace environment.

These would normally be applied to sub-sets of the complex engineering problem being analysed. For example, there may be a structure that has displayed distortion or which in the analysis shows that a solution will require additional loads. The Engineer would then apply the relevant first principle stress calculations, identifying the elements being analysed, the assumptions made on loads, the material specifications, acceptable limits etc, and have such calculations displayed in the overall analysis.

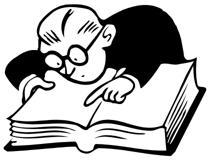


Exercise/ Topic for group discussion

The Candidate is required to demonstrate where any analytical tools have been utilized in the creation of the analysis of the complex problem being considered. Should the selected problem identified in Step 1 above not require this, then the Candidate will need to identify another complex problem for such calculations to be applied. The Candidate will need to have selected and resolved an appropriate complex problem that has to be used for the creation of a solution (per Outcome 2). The use of calculations and mathematical derivations will be required to be shown.

STEP 6: Evaluate result of analysis, using judgment

At this point in the process of creating an analysis of a complex engineering problem, we should have sufficient documented evidence to evaluate the analysis using engineering judgment. The candidate is confronted with the challenge of selecting the right solution from the evidence. It will be normal for more than one potential solution to emerge. Evaluation of the best solution will now be affected by commercial, legal, safety, environmental and possibly social or ethical influences. The Candidate will need to clearly articulate the various solutions available, define the priorities that are to apply, interrogate the preferred solution with the influences listed above and make a final selection for the desired solution.

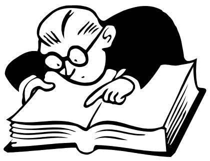


Exercise/ Topic for discussion

The Candidate is required to present a comparison of the options available for a solution from the analysis, rank them in terms of preferred option. This must include a recommended approach to the preferred solution.

STEP 7: Express understanding emerging from analysis

In this step, the candidate is required to review the analysis describing the reasons for selecting the preferred solution option. The Candidate may have consulted his peers, supervisor or mentor and should comment on the input or advice received during the analysis process. It should refer to the Candidate's degree of understanding of the problem, the process used to carry out the analysis and any risks that may be implicit in the final choice of solution.



Exercise/ Topic for discussion

The Candidate is required to present a summary report covering the overall understanding of the analysis and the conclusions.

1. *Has the Candidate understood each of the 7 steps and the reasons for them?*
2. *Does the Candidate feel that the process is rational?*
3. *Does the Candidate feel that the process is incomplete, inapplicable, overstated or deficient in any way, and could the Candidate suggest improvements?*
4. *Has any evidence emerged that could be said to have been influenced by prejudice, ego, precipitous thinking or other common traits that affect analysis?*

ASSESSMENT TEST

Complete the Assessment Test in Appendix 1 (30 minutes are allocated for this).

GROUP ACTIVITY

Report and 10 minute presentation evaluation.

CLASS DISCUSSION

Discuss Case Studies (Appendix 2) and Programme administration.

SECTION 3

GENERIC GUIDING PRINCIPLES

GENERIC GUIDING PRINCIPLES

1. Competency Standard

The SAIMechE Competency Standard is the fundamental document underpinning the journey to Professional Competence. It is the foundation document informing all aspects of the training programme that relates the requirements of competency to the working environment of the developing engineer. It is the standard of practice against which all activities of a competent and professional engineer are measured.

2. Outcomes

The eleven outcomes are the fundamental building blocks on the path to competency. A demonstration of understanding of these outcomes as they relate to the day-to-day working environment will indicate that a level of competency has been reached which will enable the candidate to function at a professional level within the commercial and business environment.

3. Assessment Criteria

The assessment criteria are the requirements against which the candidate is evaluated in order to determine understanding and competency. These are objective criteria which will ensure capability and transparency and set a standard that ensures a proficient level of competency and professionalism as required by industry and in the interests of public health and safety.

4. Range Statements

The range statements set the boundaries of the requirements of each outcome and determine the limits of competency as required for professional practice.

APPENDICES

APPENDIX 1: ASSESSMENTS/TESTS

INITIAL TEST (SECTION 1)

1. In your own words, describe a complex engineering problem.

2. List 5 common components of complex engineering problems.

3. Do you believe methodology is necessary in analysing complex engineering problems? If so, why?

4. Describe any negative concepts that commonly emerge from analysing complex engineering problems?

5. Which, if any, of the “think and analyse” tools do you feel appeal to you, and which could you use in the workplace?

6. How would you go about differentiating between cause and effect?

7. In which non-engineering environments do you think the disciplines of structured analysis could be applied?

8. How do codes and standards impact on the job of the Engineer?

9. Why is empirical thinking necessary for the Engineer?

10. What methods would you adopt to assess the competence of an Engineer after, say, 3 to 4 years of practice?

ASSESSMENT TEST (SECTION 2)

1. Identify 5 characteristics of a complex engineering problem.

2. What do you understand by the term “rational”?

3. How would you categorize the data you collect about a problem?

4. What types of processes can you identify that will assist with analysing data?

5. Should the assumptions made during analysis be validated, and if so when?

6. Does the candidate envisage the theory learnt during the tertiary degree will be useful in solving workplace problems? If so, which of the theories do you feel will be required to be used most often?

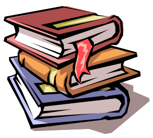
7. What are the factors that have to be taken into consideration when developing the analysis of a complex engineering problem?

8. What processes should the Engineer follow to assess the integrity of an analysis?

9. Are you able, in your own words if necessary, to recall and list below the 7 assessment criteria that apply to Outcome 1?

APPENDIX 2: CASE STUDIES

REFERENCES



Websites:

The Formation of the Engineer for the 21St Century – A Global Perspective
http://aaee.com.au/conferences/AAEE2009/PDF/AUTHOR/AE091001.PDF

Graduate Attributes and Professional Competencies
http://www.washingtonaccord.org/IEA-Grad-Attr-Prof-Competencies-v2.pdf

The six step decision making model
http://www.scribd.com/doc/906096/The-SixStep-Rational-DecisionMaking-Model

The Kepner Tregoe decision making model
http://www.decision-making-confidence.com/kepner-tregoe-decision-making.html

12 Angry Men (a 96 minute movie)
http://www.youtube.com/watch?v=s0NlNOI5LG0

Mechanical Engineer's DSTG document
http://www.ecsa.co.za/documents/NewReg/R-05-MEC-PE.pdf

RECORDING OF REPORTS

Formats for recording the portfolio of evidence

During the course of the candidate phase training, the Candidate will accumulate a portfolio of evidence comprising the reports supporting the various exercises covered in these guidelines for each Outcome.

Note that the PDP Administration will provide a web site document system that will allow the candidate to store all the PDP documents created as a back-up facility and will enable the candidate to allow access by the Mentor for any reviews that are required.

ASSESSMENT PROCESS

Guide to the Candidate

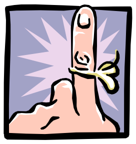
You will be assessed against Outcome 1.

In order to determine your level of competence you will be tested by:

- Tests done during the workshop and evaluated by fellow candidates and your mentor
- Written assignments (practical tasks given to demonstrate understanding of this Outcome through application in a work setting)
- Knowledge assessment and presentation (i.e. 10 minutes oral presentation using Power Point). Please Note: Oral presentations may need to be taped for moderation and re-assessment procedures.

You will need to prepare yourself in the following ways:

- Familiarise yourself with the contents of this guideline
- Familiarise yourself with the reporting formats required
- Familiarise yourself with the references listed
- Do the written assignments as required by this workshop
- For oral presentations of reports, a ten minute presentation is required to summarise the exercise performed



<u>Note:</u>

A detailed briefing on the exact requirements was given to you by the Mentor/Assessor at the Introductory Workshop in order for you to prepare for the assessment process.

The evidence you will be judged on includes:

- Your proven competence in all areas questioned in the presentation (Competent or Not Yet Competent)
- The practical tasks compiled in your Portfolio of Evidence

Good luck, and remember, the mentor/assessor is there to help you.