UMALUSI

COUNCIL FOR QUALITY ASSURANCE IN GENERAL AND FURTHER EDUCATION AND TRAINING

Exemplar Book on Effective Questioning

Mechanical Technology

Compiled by the Statistical Information and Research (SIR) Unit

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PREFACE

The National Senior Certificate (NSC) examinations are set and moderated in part using tools which specify the types of cognitive demand and the content deemed appropriate for Mechanical Technology at Grade 12 level. Until recently, the level of cognitive demand made by a question was considered to be the main determinant of the overall level of cognitive challenge of an examination question.

However, during various examination evaluation projects conducted by Umalusi from 2008-2012, evaluators found the need to develop more complex tools to distinguish between questions which were categorised at the same cognitive demand level, but which were not of comparable degrees of difficulty. For many subjects, for each type of cognitive demand a three-level degree of difficulty designation, *easy, moderate and difficult* was developed. Evaluators first decided on the type of cognitive process required to answer a particular examination question, and then decided on the degree of difficulty, *as an attribute of the type of cognitive demand*, of that examination question.

Whilst this practice offered wider options in terms of *easy, moderate* and *difficult* levels of difficulty for each type of cognitive demand overcame some limitations of a one-dimensional cognitive demand taxonomy, other constraints emerged. Bloom's Taxonomy of Educational Objectives (BTEO) (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956) and the Revised Bloom's Taxonomy are based on the assumption that a cumulative hierarchy exists between the different categories of cognitive demand (Bloom et al., 1956; Bloom, Hastings & Madaus, 1971). The practice of 'levels of difficulty' did not necessarily correspond to a hierarchical model of increasing complexity of cognitive demand. A key problem with using the level of difficulty as an attribute of the type of cognitive demand of examination questions is that, questions recognised at a higher level of cognitive demand are not necessarily categorised as more difficult than other questions categorised at lower levels of cognitive demand. For example, during analyses a basic recognition or

recall question could be considered more difficult than an easy evaluation question.

Research further revealed that evaluators often struggled to agree on the classification of questions at so many different levels. The finer categorization for each level of cognitive demand and the process of trying to match questions to pre-set definitions of levels of difficulty made the process of making judgments about cognitive challenge overly procedural. The complex two-dimensional multi-level model also made findings about the cognitive challenge of an examination very difficult for Umalusi Assessment Standards Committee (ASC) to interpret.

In an Umalusi Report, *Developing a Framework for Assessing and Comparing the Cognitive Challenge of Home Language Examinations* (Umalusi, 2012), it was recommended that the type and level of cognitive demand of a question and the level of a question's difficulty should be analysed separately. Further, it was argued that the ability to assess cognitive challenge lay in experts' abilities to recognise subtle interactions and make complicated connections that involved the use of multiple criteria simultaneously. However, the tacit nature of such judgments can make it difficult to generate a common understanding of what constitutes criteria for evaluating the cognitive challenge of examination questions, despite descriptions given in the policy documents of each subject.

The report also suggested that the Umalusi external moderators and evaluators be provided with a framework for thinking about question difficulty which would help them identify where the main sources of difficulty or ease in questions might reside. Such a framework should provide a common language for evaluators and moderators to discuss and justify decisions about question difficulty. It should also be used for building the capacity of novice or less experienced moderators and evaluators to exercise the necessary expert judgments by making them more aware of key aspects to consider in making such judgments.

The revised Umalusi examination moderation and evaluation instruments for each subject draw on research and literature reviews, together with the knowledge gained through the subject workshops. At these workshops, the proposed revisions were discussed with different subject specialists to attain a common understanding of the concepts, tools and framework used; and to test whether the framework developed for thinking about question difficulty 'works' for different content subjects. Using the same framework to think about question difficulty across subjects will allow for greater comparability of standards across subjects and projects.

An important change that has been made to the revised examination evaluation instrument is that the analysis of *the type of cognitive demand* of a question and analysis of *the level of difficulty* of each question are now treated as two separate judgments involving two different processes. Accordingly, the revised examination evaluation instrument now includes assessment of difficulty *as well as* cognitive demand.

LIST OF ABBREVIATIONS

Abbreviation	Full name
ASC	Assessment Standards Committee
BTEO	Bloom's Taxonomy of Educational Objectives
CAPS	Curriculum Assessment Policy Statement
DBE	Department of Basic Education
FET	Further Education and Training
IEB	Independent Examinations Board
NSC	National Senior Certificate
NQF	National Qualifications Framework
QAA	Quality Assurance of Assessment
QCC	Qualifications, Curriculum and Certification
SIR	Statistical Information and Research

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ACKNOWLEDGEMENTS

This Mechanical Technology exemplar book is informed by Umalusi Research Reports of previous years, especially the report by Reeves (Umalusi, 2012) titled '*Developing a framework for assessing and comparing the cognitive challenge of Home Language examinations*'.

In addition, Mechanical Technology subject experts and practitioners are acknowledged for their contribution to the content of this exemplar book. Included in this group are: Umalusi External Moderators and Maintaining Standards Subject Teams and Team Leaders; together with the South African Comprehensive Assessment Institute and the Independent Examinations Board (IEB) Examiners and Internal Moderators.

We also acknowledge the contributions of the members of the Umalusi Quality Assurance of Assessment (QAA); Qualifications, Curriculum and Certification (QCC) and Statistical Information and Research (SIR) Units. We specifically acknowledge the contribution made by the individuals listed below:

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- The review team included the following members: Mr Aubrey Khosa, Prof. Desmond Govender and Ms Wilma Uys.

This exemplar book was prepared by Mr Pragasen Naidoo.

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1. INTRODUCTION

The rules of assessment are essentially the same for all types of learning because, to learn is to acquire knowledge or skills, while to assess is to identify the level of knowledge or skill that has been acquired (Fiddler, Marienau & Whitaker, 2006). Nevertheless, the field of assessment in South Africa and elsewhere in the world is fraught with contestation. A review of the research literature on assessment indicates difficulties, misunderstanding and confusion in how terms describing educational measurement concepts, and the relationships between them, are used (Frisbie, 2005).

Umalusi believes that if all role players involved in examination processes can achieve a common understanding of key terms, concepts and processes involved in setting, moderating and evaluating examination papers, much unhappiness can be avoided. This exemplar book presents a particular set of guidelines for both novice and experienced Mechanical Technology national examiners, internal and external moderators, and evaluators to use in the setting, moderation and evaluation of examinations at the National Senior Certificate (NSC) level.

The remainder of the exemplar book is organised as follows: First, the context in which the exemplar book was developed is described (Part 2), followed by a statement of its purpose (Part 3). Brief summaries of the roles of moderation and evaluation (Part 4) and cognitive demand (Part 5) an assessment. Examination questions selected from the NSC Mechanical Technology examinations of assessment bodies, the Department of Basic Education (DBE), and/or the Independent Examinations Board (IEB) are used to illustrate how to identify different levels of cognitive demand as required by the Curriculum and Assessment Policy Statement (CAPS) Mechanical Technology document (Part 6). Part 7 explains the protocols for identifying different levels of difficulty within a question paper. Application of the Umalusi framework for determining

difficulty described in Part 7 is illustrated, with reasons, by another set of questions from a range of Mechanical Technology examinations (Part 8). Concluding remarks complete the exemplar book (Part 9).

2. CONTEXT

Umalusi has the responsibility to quality assure qualifications, curricula and assessments of National Qualification Framework (NQF) Levels 1 - 5. This is a legal mandate assigned by the *General and Further Education and Training Act (Act 58 of 2001)* and the *National Qualification Framework Act (Act 67 of 2008)*. To operationalize its mandate, Umalusi, amongst other things, conducts research and uses the findings of this research to enhance the quality and standards of curricula and assessments.

Since 2003, Umalusi has conducted several research studies that have investigated examination standards. For example, Umalusi conducted research on the NSC examinations, commonly known as 'Matriculation' or Grade 12, in order to gain an understanding of the standards of the new examinations (first introduced in 2008) relative to those of the previous NATED 550 Senior Certificate examinations (Umalusi, 2009a, 2009b). Research undertaken by Umalusi has assisted the organisation to arrive at a more informed understanding of what is meant by assessing the cognitive challenge of the examinations and of the processes necessary for determining whether the degree of cognitive challenge of examinations is comparable within a subject, across subjects and between years.

Research undertaken by Umalusi has revealed that different groups of examiners, moderators and evaluators do not always interpret cognitive demand in the same way, posing difficulties when comparisons of cognitive challenge were required. The research across all subjects also showed that

using the type and level of cognitive demand of a question *only* as measure for judging the cognitive challenge of a question is problematic because cognitive demand levels on their own do not necessarily distinguish between degrees of difficulty of questions.

The new Umalusi framework for thinking about question difficulty described in this exemplar book is intended to support all key role players in making complex decisions about what makes a particular question challenging for Grade 12 examination candidates.

3. THE PURPOSE OF THE EXEMPLAR BOOK

The overall goal of this exemplar book is to ensure the consistency of standards of examinations across the years in the Further Education and Training (FET) sub-sector and Grade 12, in particular. The specific purpose is to build a shared understanding among teachers, examiners, moderators, evaluators, and other stakeholders, of methods used for determining the type and level of cognitive demand as well as the level of difficulty of examination questions.

Ultimately, the common understanding that this exemplar book seeks to foster is based on the premise that the process of determining the type and level of cognitive demand of questions and that of determining the level of difficulty of examination questions are two separate judgements involving two different processes, both necessary for evaluating the cognitive challenge of examinations. This distinction between cognitive demand and difficulty posed by questions needs to be made in the setting, moderation, evaluation and comparison of Mechanical Technology examination papers.

The exemplar book includes an explanation of the new Umalusi framework which is intended to provide all role-players in the setting of Mechanical Technology examinations with a common language for thinking and talking

about question difficulty. The reader of the exemplar book is taken through the process of evaluating examination questions; first in relation to determining the type and level of cognitive demand made by a question, and then in terms of assessing the level of difficulty of a question. This is done by providing examples of a range of questions which make different types of cognitive demands on candidates, and examples of questions at different levels of difficulty.

Each question is accompanied by an explanation of the reasoning behind why it was judged as being of a particular level of cognitive demand or difficulty, and the reasoning behind the judgements made is explained. The examples of examination questions provided were sourced by Mechanical Technology evaluators from previous DBE and the IEB Mechanical Technology question papers, pre- and post- the implementation of CAPS during various Umalusi workshops.

This exemplar book is an official document. The process of revising the Umalusi examination evaluation instrument and of developing a framework for thinking about question difficulty for both moderation and evaluation purposes has been a consultative one, with the DBE and the IEB assessment bodies. The new framework for thinking about question difficulty is to be used by Umalusi in the moderation and evaluation of Grade 12 Mechanical Technology examinations, and by all the assessment bodies in the setting of the question papers, in conjunction with the CAPS documents.

4. MODERATION AND EVALUATION OF ASSESSMENT

A fundamental requirement, ethically and legally, is that assessments are fair, reliable and valid (American Educational Research Association [AERA], American Psychological Association [APA] and National Council on Measurement in Education [NCME], 1999). Moderation is one of several quality

assurance assessment processes aimed at ensuring that an assessment is fair, reliable and valid (Downing & Haladyna, 2006). Ideally, moderation should be done at all levels of an education system, including the school, district, provincial and national level in all subjects.

The task of Umalusi examination **moderators** is to ensure that the quality and standards of a particular examination are maintained each year. Part of this task is for moderators to alert examiners to details of questions, material and/or any technical aspects in examination question papers that are deemed to be inadequate or problematic and that therefore, challenge the validity of that examination. In order to do this, moderators need to pay attention to a number of issues as they moderate a question paper – these are briefly described below.

Moderation of the technical aspects of examination papers includes checking correct question and/or section numbering, and ensuring that visual texts and/or resource material included in the papers are clear and legible. The clarity of instructions given to candidates, the wording of questions, the appropriateness of the level of language used, and the correct use of terminology need to be interrogated. Moderators are expected to detect question predictability, for example, when the same questions regularly appear in different examinations, and bias in examination papers. The adequacy and accuracy of the marking memorandum (marking guidelines) need to be checked to ensure that they reflect and correspond with the requirements of each question asked in the examination paper being moderated.

In addition, the task of moderators is to check that papers adhere to the overall examination requirements as set out by the relevant assessment body with regard to the format and structure (including the length, type of texts or reading selections prescribed) of the examination. This includes assessing compliance with assessment requirements with regard to ensuring that the

content is examined at an appropriate level and in the relative proportions (weightings) of content and/or skills areas required by the assessment body.

The role of Umalusi examination **evaluators** is to perform analysis of examination papers after they have been set and moderated and approved by the Umalusi moderators. This type of analysis entails applying additional expert judgments to evaluate the quality and standard of finalised examination papers before they are written by candidates in a specific year. However, the overall aim of this evaluation is to judge the comparability of an examination against the previous years' examination papers to ensure that consistent standards are being maintained over the years.

The results of the evaluators' analyses, and moderators' experiences provide the Umalusi Assessment Standards Committee (ASC) with valuable information which is used in the process of statistical moderation of each year's examination results. Therefore, this information forms an important component of essential qualitative data informing the ASC's final decisions in the standardisation of the examinations.

In order for the standardisation process to work effectively, efficiently and fairly, it is important that examiners, moderators and evaluators have a shared understanding of how the standard of an examination paper is assessed, and of the frameworks and main instruments that are used in this process.

5. COGNITIVE DEMANDS IN ASSESSMENT

The *Standards for educational and psychological testing* (AERA, APA, & NCME, 1999) require evidence to support interpretations of test scores with respect to cognitive processes. Therefore, valid, fair and reliable examinations require that the levels of cognitive demand required by examination questions are appropriate and varied (Downing & Haladyna, 2006). Examination papers

should not be dominated by questions that require reproduction of basic information, or replication of basic procedures, and under-represent questions invoking higher level cognitive demands.

Accordingly, the Grade 12 CAPS NSC subject examination specifications state that examination papers should be set in such a way that they reflect proportions of marks for questions at various level of cognitive demand. NSC examination papers are expected to comply with the specified cognitive demand levels and weightings. NSC examiners have to set and NSC internal moderators have to moderate examination papers as reflecting the proportions of marks for questions at different levels of cognitive demand as specified in the documents. Umalusi's external moderators and evaluators are similarly tasked with confirming compliance of the examinations with the CAPS cognitive demand levels and weightings, and Umalusi's revised examination evaluation instruments continue to reflect this requirement.

Despite that, subject experts, examiners, moderators and evaluators are familiar with the levels and explanations of the types of cognitive demand shown in the CAPS documents, Umalusi researchers have noted that individuals do not always interpret and classify the categories of cognitive demand provided in the CAPS the same way. In order to facilitate a common interpretation and classification of the cognitive demands made by questions, the next section of this exemplar book provides a clarification of each cognitive demand level for Mechanical Technology followed by illustrative examples of examination questions that have been classified at that level of cognitive demand.

6. EXPLANATIONS AND EXAMPLES OF QUESTIONS ASSESSED AT THE DIFFERENT COGNITIVE DEMAND LEVELS IN THE MECHANICAL TECHNOLOGY TAXONOMY ACCORDING TO CAPS

The taxonomies of cognitive demand for each school subject in the CAPS documents are mostly based on the Revised Bloom's Taxonomy (Anderson and Krathwohl, 2001) but resemble the original Bloom's taxonomy in that categories of cognitive demand are arranged along a single continuum. Bloom's Taxonomy of Educational Objectives (BTEO) (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956) and the Revised Bloom's Taxonomy imply that each more advanced or successive category of cognitive demand subsumes all categories below it. The CAPS Taxonomies of Cognitive Demand make a similar assumption (Crowe, 2012).

Note:
In classifying the type and level of cognitive demand, each question is classified at the highest level of cognitive process involved. Thus, although a particular question involves recall of knowledge, as well as comprehension and application, the question is classified as an 'analysis' question if that is the highest level of cognitive process involved. If evaluating' is the highest level of cognitive process involved, the question as a whole should be classified as an 'evaluation' question. On the other hand, if one of more sub-sections of the question and the marks allocated for each sub-section can stand independently, then the level of cognitive demand for each sub-section of the question should be analysed separately.

The CAPS documents for many subjects also give examples of descriptive verbs that can be associated with each of the levels of cognitive demand. However, it is important to note that such 'action verbs' can be associated with more than one cognitive level depending on the context of a question.

The Mechanical Technology CAPS document states that Grade 12 NSC Mechanical Technology examination papers should examine three levels of cognitive demand (Table 1).

TABLE 1: THE TAXONOMY OF COGNITIVE DEMAND LEVELS FOR THE MECHANICAL TECHNOLOGY NSC EXAMINATIONS

L1 **Lower Order**	**L2** **Middle Order**	**L3** **Higher Order**
Knowledge	**Comprehension and application**	**Analysis, evaluation and synthesis**

Source: CAPS (DBE, 2011a, p.35)

To facilitate reading of this section, each of the above cognitive demand levels in the Mechanical Technology Taxonomy are explained, and the explanation is followed by at least **three** examples of questions from previous Mechanical Technology NSC examinations classified at each of the levels of cognitive demand shown in Table 1, above. These examples were selected to represent the **best and clearest** examples of each level of cognitive demand that the Mechanical Technology experts could find. The discussion below each example question explains the reasoning processes behind the classification of the question at that particular type of cognitive demand (Table 2 to Table 4).

Note:
Be mindful that analyses of *the level of cognitive process* of a question and *the level of difficulty* of each question are to be treated as two separate judgments involving two different processes. Therefore, whether the question is easy or difficult should not influence the categorisation of the question in terms of the type and level of cognitive demand. Questions should NOT be categorised as higher order evaluation/synthesis questions because they are difficult questions. Some questions involving the cognitive process of recall or recognition may be more difficult than other recall or recognition questions. Not all comprehension questions are easier than questions involving analysis or synthesis. Some comprehension questions may be very difficult, for example explanation of complex scientific processes. For these reasons, you need to categorise the level of difficulty of questions separately from identifying the type of cognitive process involved.

Table 2: Examples of questions at Level 1: KNOWLEDGE

Example 1:
Question: November 2012 NSC Examination – Question 2,5) What does the abbreviation MIGS stand for, relative to welding/joining methods? (1)
Discussion: To answer Question 2.5, candidates have to state what the acronym MIGS stands for. In mechanical engineering, it is common practice for abbreviations/acronyms to be used. They are used extensively in engineering drawings and also to identify tools and equipment. Metal inert gas shielded (MIGS) type welding, is a type of welding process that uses a special type of gas and a coated copper wire. Grade 12 candidates should all have learnt about welding/Joining Methods and about the different abbreviations/acronyms related to welding/Joining Methods. To answer this question, candidates simply need to *remember* that MIGS refers to *Metal inert gas shielded*. This is basic content knowledge for Grade 12 candidates who should all be familiar with the acronym. The question does not require candidates to show comprehension by providing any further explanation of the welding process and is thus classified as a lower order 'knowledge' question.
Memorandum/Marking guidelines Metal Inert Gas shielded. ✓(1)
Example 2:
Question: November 2012 NSC Examination – Question 2.6 Name TWO gases that can be used in MAGS/MIGS welding. (2 marks)
Discussion: Question 2.6 requires candidates to name two types of gases used in MAGS/ MIGS welding. The action verb 'name' indicates that this could be a 'knowledge' type question. To answer the question candidates need to recall the names of the special gases used during this advanced welding process namely: argon and helium. Grade 12 candidates should have learnt this information on MIGS/MAGS welding in class, from manuals, from the Grade 12 Mechanical Technology textbook, as well as during their practical lessons. Hence, the question is classified as requiring the lower order cognitive process of recall of fundamental knowledge.
Memorandum/Marking guidelines • Argon/Ag ✓(2) • Carbon dioxide/$C0_2$ ✓ • Helium/He ✓ (Any 2 x 1)
Example 3:
Question: (November 2011 NSC Examination – Question 4.2) Andy must see to the safe handling and storage of gas cylinders. Which FOUR safety rules must he take into consideration for the safe handling and storage of the gas cylinders? (4)

Discussion:
Question 4.2 relates to the safe handling and storage of gas cylinders. In answering this question, candidates can either refer to the safe handling of cylinders, or to the safe storage of cylinders, or to both these aspects. Grade 12 candidates should have learnt about safety aspects regarding gas cylinders (safe handling and use and storage of gas cylinders) in class. To answer the question, they have to *remember* four safety rules specifically applicable when handling and/or storing gas cylinders. What they have to do to answer the question is *remember* what they have learnt in class and/or through the textbooks/resource material provided. The question is thus classified as a *recall* of fundamental *knowledge* type questions – it does not require candidates to show comprehension by providing any explanation.

Memorandum/Marking guidelines

Gas cylinders:(4)

- Store oxygen and acetylene separately. ✓
- Store full and empty cylinders apart. ✓
- Keep cylinders in a cool place away from heat. ✓
- Place cylinders in an upright position. ✓
- Don't drop cylinders. ✓
- Cylinder heads must be on. ✓
- Keep cylinders away from oil or grease. ✓
- Don't hammer on cylinders. ✓
- Secure cylinders properly. ✓
- Do not transport in horizontal position. ✓(Any 4 X 1)

Table 3: Examples of questions at level 2: COMPREHENSION & APPLICATION

Example 1

Question

November 2014 NSC Examination – Question 6.2

Explain the procedure followed during a nick break test on a welded joint. (5)

Discussion:
Grade 12 candidates should all have learnt about the two main classes of tests that could be done on welded joints, namely destructive and non-destructive tests. They learn this information in class, from manuals and from their Grade 12 Mechanical Technology textbooks. They also should have carried out the tests in their practical assessment task during their practical lessons in the Mechanical Technology workshop. However, to answer this, they have to do more than recall the names of the classes of tests; they have to show that they understand the procedure by explaining step by step how a nick break test is carried out on a welded joint. Thus, the question is classified as a 'comprehension' type question rather than a 'knowledge' question (middle order).

Memorandum/Marking guidelines

Nick break test: (5)

- Each edge of the weld is slotted by means of a saw. ✓
- Place the specimen on two steel supports. ✓

- Use a hammer to break the specimen by striking it in the zone where the cut was made. ✓
- The weld metal exposed should be completely fused, free from slag inclusions and contain no gas pockets greater than 1,6 mm. ✓
- There should not be more than one pore or gas pocket per square centimetre. ✓

Example 2:

Question

November 2012NSC Examination – Question 5.4.2

The performance of smaller engines can be improved by using superchargers.

FIGURE 5.2

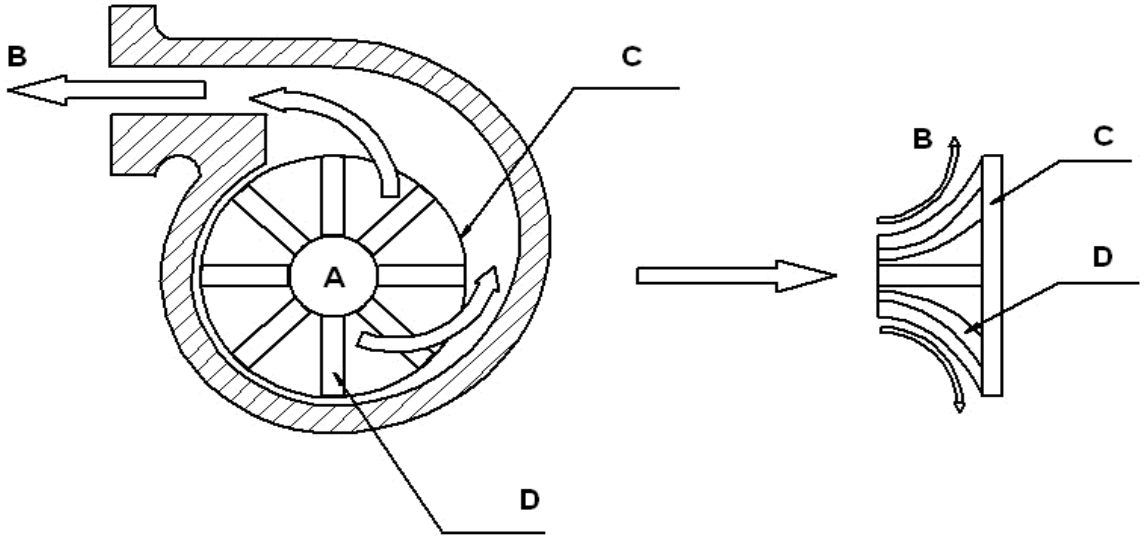


FIGURE 5.2

Explain the operation of the supercharger shown in FIGURE 5.2. (5 marks)

Discussion:

In Grade 12, candidates learn about turbo- and superchargers, both of which are widely used in the Motor Engineering industry today. This specialized equipment enhances the performance of motor vehicles. Both trucks and cars use either turbo chargers and/or super chargers for better performance and speed. Greater skill and training is required to correctly install them in a motor vehicle. Safety rules and regulations are put in place to ensure that the turbo chargers or super chargers are correctly fitted on motor cars and trucks as per government regulations. Grade 12 candidates should understand the working principles and the advantages gained by using either turbochargers and or superchargers. To explain how the supercharger works, candidates have to correctly recall and recognize the various parts of the supercharger shown in Figure 5.2. However, they also have to understand the uses and function of the different parts of the supercharger. Answering this question goes beyond remembering facts (knowledge); it entails using understanding to explain the working principles behind the process. The action verb 'explain' suggests that this is a 'comprehension' question. This question is therefore classified as a middle order question.

Memorandum/Marking guidelines

Operation: (5)

- The engine drives the rotor. ✓
- Air is drawn in behind the rotor. ✓
- The air is forced around into a decreasing volume. ✓
- This raises the pressure of the air. ✓
- The air is forced into the inlet manifold and into the cylinders. ✓

Example 3:

Question: (November 2012 NSC Examination – Question 2.4)

The function of the cylinder leakage tester is to check whether the engine leaks gases from the cylinder during compression strokes. State THREE possible leakages that could occur during the cylinder leakage test and state the causes of each. (6)

Discussion:

Question 2.4 is about advanced tools, namely the cylinder leakage tester. To answer the question, candidates need to recall information on regulations regarding the care and use of the cylinder leakage tester. They have to identify three possible areas were leakage can occur in a motor vehicle and explain the causes of gas leakage that can occur during the compression stroke of the engine cycle. To do this, candidates have to *understand* the working principles of a four-stroke petrol engine and the areas where problems could occur, and what should be done to correct the fault. Thus, although the action verb 'state' suggests that this may be a simple recall or recognition of knowledge question, answering this question goes beyond merely remembering facts (knowledge). Candidates require a deeper understanding and be able to explain the area of leakage relative to the cause. This question is classified as being a middle order question.

Memorandum/Marking guidelines

- Listen at the carburettor and/or inlet manifold for hissing noise. ✓
  (inlet valve is leaking). ✓
- Listen to the exhaust pipe or exhaust manifold for a hissing noise. ✓
  (exhaust pipe is leaking). ✓
- Listen for hissing noise in the dipstick hole. ✓
  (piston rings worn). ✓
- Remove the filler cap on the tappet cover and listen for hissing noise. ✓
  (rings are worn). ✓
- If you see bubbles in the radiator water. ✓
  (the cylinder head gasket is blown or the cylinder block is cracked). ✓

(Any 3 x 2)

Table 4: Examples of questions at level 3: ANALYSIS, EVALUATION AND SYNTHESIS

Example 1:

Question

(November 2008 NSC Examination – Question 4.2)

You are a designer and it is required of you to use various alloys in your projects. Compare the compositions and properties of the following non-ferrous alloys:

a) Aluminium bronze
b) Duralumin
c) Carbon fibre 3x2 = 6 marks

Discussion:

Various types of materials are used in the mechanical engineering industry. These materials have extremely high load carrying capacity and have different properties. Candidates should have learnt about these materials in the classroom and from reading their Mechanical Technology textbooks as well as from other relevant manuals and videos. To answer this question, candidates must compare the composition and the properties of each of the materials listed. They must able to break down the information acquired in the previous sentence in order to identify the composition and properties of the material listed. In this question, candidates must make deductions based on their understanding and application of these non-ferrous alloys. Candidates need to make critical judgements on the composition and properties to design a project requires higher order thinking skills.

Memorandum/Marking guidelines

Alloy	Composition	Properties
Aluminium Bronze	**Consists of copper and aluminium** ✓	**Any one of the following:** • **Ductile** ✓ • **Malleable** ✓ • **Corrosion resistant**✓ • **Tough** ✓ • **Hard** ✓ (Any 1 answer)
Duralumin	**Consists of copper and Manganese, magnesium and aluminium** ✓	**Any one of thefollowing:** • **Very strong** ✓ • **Light** ✓ • **Hardens with age** ✓ (Any 1 answer)
Carbon fibres	**Produced from polymere PAN(Polyacrylonitrile)** ✓	**Any one of the following:** • **Low density** ✓ • **Light weight** ✓ • **Resistant to corrosion** ✓ • **Stiffest and strongest reinforcing fibre** ✓ (Any 1 answer)

(6)

Example 2:

Question:

(Example formulated by subject expert for the purpose of this manual)

A mechanical engineer is required to design a compound gear train for a tool making machine. The input shaft is dissipating 5 kW of power at a speed of 840 Rpm. The customer requires that the machine produce a minimum torque of 200 Nm at a speed of 200 Rpm. The following gears must be used to build up the gear train (35 T; 86T; 43T; & 70 T). The gears must be arranged so that when assembled it will form the gear train that will satisfy the customers need.

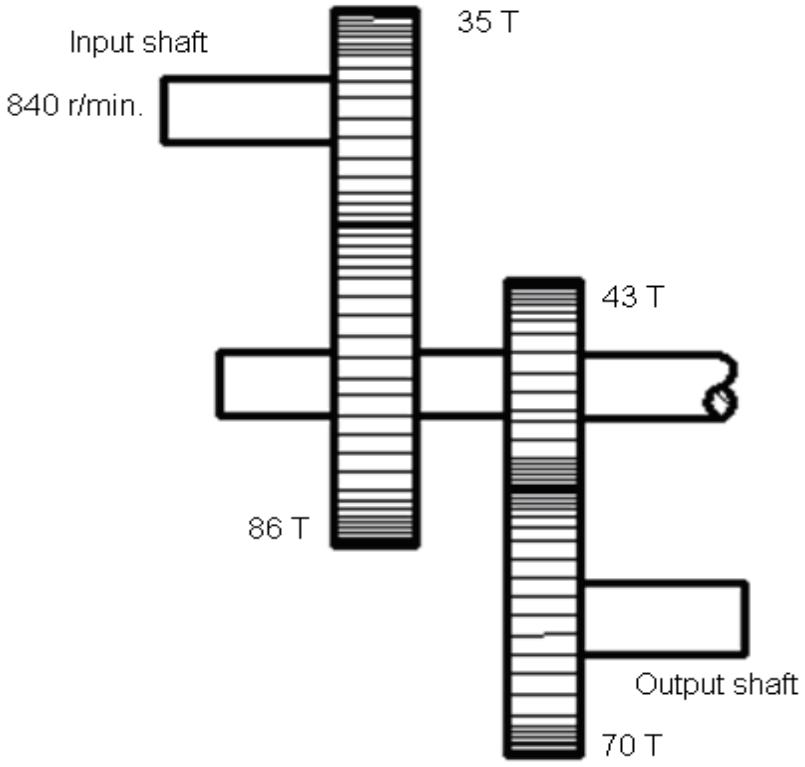
2.1.1 Sketch and label the gear train. (3)
2.1.2 Calculate the actual torque at the output. (3)
2.1.3 Calculate the output speed. (4)

2.1.4 Is the gear train suitable for the customer? Motivate your answer. (3)

Discussion:
Grade 12 candidates should all have learnt about compound gear trains and how to perform calculations on gears and gear drives in class and from reading their Mechanical Technology textbooks as well as from other relevant manuals and videos. A compound gear train must be designed using the given selection of gears. To answer sub-question 2.1.1, candidates have to sketch a gear train using the supplied gears. They have to apply their knowledge to arrange and assemble a compound gear train that satisfies the design requirements. Answering 2.1.1 entails analysing how gear principles work in mechanical engineering and synthesizing all the information provided in the source material to create the sketch where the design will meet the customer's requirements. Answering sub-questions 2.1.2 and 2.1.3 requires more than merely applying a formula and adding figures, it involves abstract interpretation and reasoning. Firstly, candidates have to analyse, select, synthesise and use the relevant information from the question to create the sketch. The sketch is necessary to proceed with the calculations. Candidates have to identify and apply the correct formula for each of the required calculations. To answer 2.1.4, candidates have to analyse and synthesise all the information from the answers to the previous questions (i.e. the sketch and the results of their calculations) to assess/evaluate and justify why the system they have designed is suitable for the particular operation or not. This question is classified as a higher order question.

Memorandum/Marking guidelines

2.1.1



(3) ✓✓✓

2.1.2

$$\text{Power} = \frac{2 \times \pi \times N \times T}{60}$$ ✓(3)

Torque = 5000 x 60 ✓
2 x π x 210

= 227,36 Nm ✓

2.1.3

Input speed= No of teeth on driven gears ✓(4)
Output speed = No of teeth on driven gears

Out speed = 840 rpm x 86 x 70 ✓✓
35 x 43

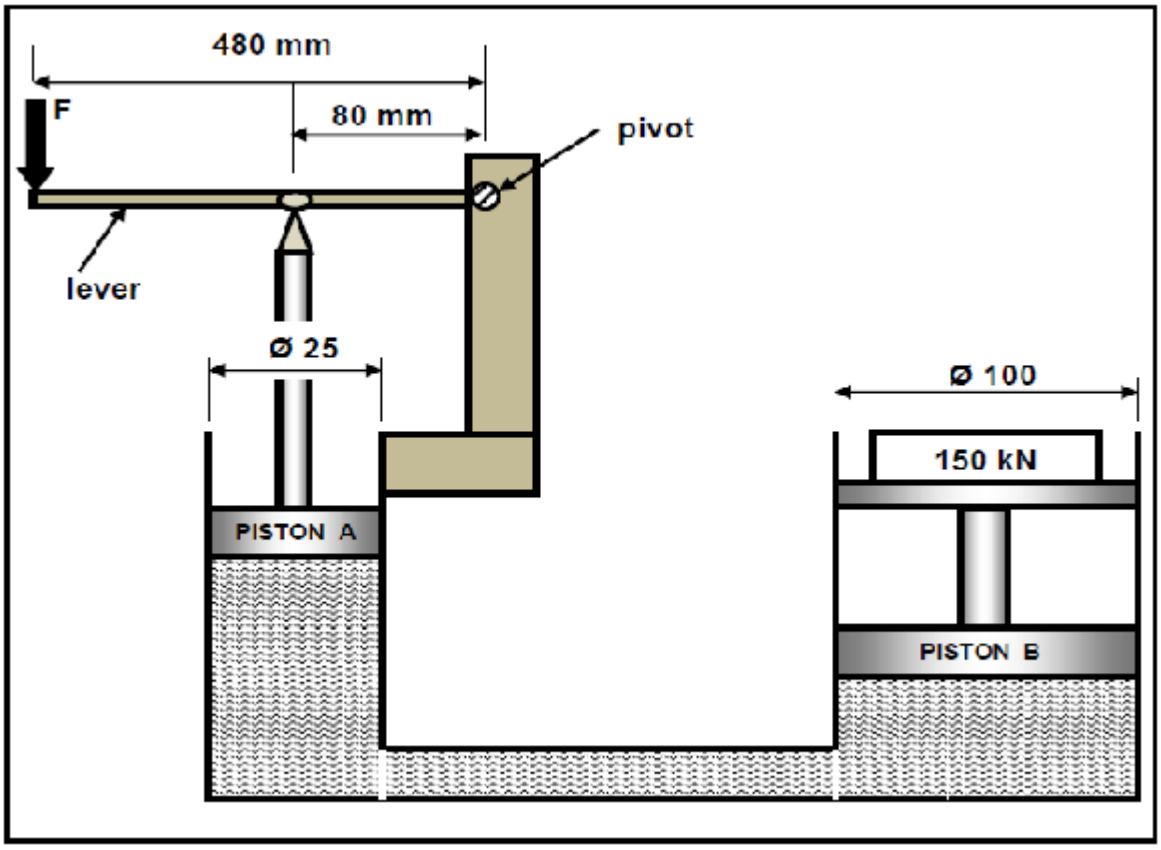
= 210 rpm ✓

2.1.4
Yes,✓ it is suitable for the gear train because both the spindle speed and torque are higher than the desired/required one. ✓✓(3)

Example 3:

Question:
(Example formulated by subject expert for the purpose of this manual)
A lever- controlled hydraulic system with specifications is shown diagrammatically in FIGURE 2.1 below. Critically analyse the given data. The load on piston "A" must not exceed 150 kilo Newtons, the diameter of piston "B" must be four times the diameter of piston "A". The safe working load necessary to work this lever system must not exceed 900 N.
Answer the following questions.

3.1 Calculate the safe working load (F) that will work this lever system. (12)



Discussion:
The hydraulic driven machine has an extremely high load carrying capacity. Engineers calculate the safe working load capacity of the hydraulic system and then determine the load the lever can carry. All Grade 12 candidates should have learnt about calculations using hydraulics principles in the classroom and from reading their Mechanical Technology textbooks as well as from other relevant manuals and videos. Candidates must be aware that other calculations such as area, fluid pressure and load of the hydraulic system on piston "A" is necessary to calculate the load on the lever system.

The process includes applying Boyle's law and analysing how the hydraulic principle works. Candidates also have to apply the knowledge of the working principles of a lever operating system.

Candidates have to analyse all the information provided in Figure 2.1. They then have to select and synthesise the relevant information to calculate the safe load on the lever system. They also have to identify and apply the correct formula for each of the required calculations. The process involves abstract interpretation and reasoning. However, in this question candidates also have to make a judgment as to whether or not this lever system is safe for the particular operation. Therefore, this question is classified as higher order.

Memorandum/Marking guidelines Example 3:

2.1.1 **Area B =πD^2** (4)

4

$= \frac{\pi (0,1)^2}{4}$ ✓

$= 7,85 \times 10^{-3}\ m^2$ ✓

Pressure $= \frac{\text{Force}_B}{\text{Area}_B}$

$= \frac{150000}{7,85 \times 10^{-3}\ m^2}$ ✓

$= 19,11\ MPa$ ✓

2.1.2 **Area A** $= \frac{\pi D^2}{4}$ (4)

$= \frac{\pi (0,025)^2}{4}$ ✓

$= 0,49 \times 10^{-3}\ m^2$ ✓

Force A = Pressure x Area$_A$

$= 19,11\ MPa \times 0,49 \times 10^{-3}\ m^2$ ✓

= 9363,9 N ✓

2.1.3 **F x 0,48 = 9363,9 N x 0,08** ✓✓ (4)

$F = \frac{9363,9\ N \times 0,08}{0,48}$ ✓

F = 1560,65 N ✓

To accomplish the goal of discriminating between high achievers, those performing very poorly, and all candidates in between, examiners need to vary the challenge of examination questions. Until recently, the assumption has been that 'alignment' with the allocated percentage of marks for questions at the required cognitive demand levels meant that sufficient examination questions were relatively easy; moderately challenging; and difficult for candidates to answer.

However, research and candidate performance both indicate that a range of factors other than type of cognitive demand contribute to the cognitive challenge of a question. Such factors include the level of content knowledge

required, the language used in the question, and the complexity or number of concepts tested. In other words, cognitive demand levels on their own do not necessarily distinguish between degrees of difficulty of questions.

This research helps, to some extent, explain why, despite that some NSC examination papers have complied with the specified cognitive demand weightings stipulated in the policy, they have not adequately distinguished between candidates with a range of academic abilities in particular between higher ability candidates. As a result, examiners, moderators and evaluators are now required to assess the difficulty level of each examination question in addition to judging it's cognitive demand.

Section 7 below explains the new protocol introduced by Umalusi for analysing examination question difficulty.

7 ANALYSING THE LEVEL OF DIFFICULTY OF EXAMINATION QUESTIONS

When analysing the level of difficulty of each examination question, there are six important protocols to note. These are:

1. Question difficulty is **assessed independently** of the type and level **of cognitive demand**.
2. Question difficulty is assessed against **four levels of difficulty**.
3. Question difficulty is determined against the assumed capabilities of the **ideal** '**envisaged'** Grade 12 Mechanical Technology NSC examination **candidate**.
4. Question difficulty is determined using **a common framework** for thinking about question difficulty.
5. Question difficulty entails **distinguishing unintended sources of difficulty** or ease **from intended sources of difficulty** or ease.
6. Question difficulty entails identifying **differences** in levels of difficulty **within a single question**.

Each of the above protocols is individually explained and discussed below.

7.1 Question difficulty is assessed independently of the type and level of cognitive demand

As emphasised earlier in this exemplar book, the revised Umalusi NSC examination evaluation instruments separate the analysis of the type of cognitive demand of a question from the analysis of the level of difficulty of each examination question. Cognitive demand describes the *type of cognitive process* that is required to answer a question, and this does not necessarily equate or align with the *level of difficulty* of other aspects of a question, such as the difficulty of the content knowledge that is being assessed. For example, a recall question can ask a candidate to recall very complex and abstract scientific content. The question would be categorised as Level 1 in terms of the cognitive demand taxonomy but may be rated as 'difficult' (Level 3 Table 5 below).

Note:

Cognitive demand is just one of the features of a question that can influence your comparative judgments of question difficulty. The type and level of cognitive process involved in answering a question does not necessarily determine how difficulty the question would be for candidates. Not all evaluation/synthesis/analysis questions are more difficult than questions involving lower-order processes such as comprehension or application.

7.2 Question difficulty is assessed at four levels of difficulty

The revised Umalusi NSC examination evaluation instruments require evaluators to exercise expert judgments about whether each examination question is 'Easy', 'Moderately challenging', 'Difficult' or 'Very difficult' for the envisaged Grade 12 learner to answer. Descriptions of these categories of difficulty are shown in Table 5.

TABLE 5 LEVELS OF DIFFICULTY OF EXAMINATION QUESTIONS

1	2	3	4
Easy for the envisaged Grade 12 student to answer.	**Moderately challenging** for the envisaged Grade 12 student to answer.	**Difficult** for the envisaged Grade 12 student to answer.	**Very difficult** for the envisaged Grade 12 student to answer. The skills and knowledge required to answer the question allow for the top students (*extremely* high-achieving/ability students) to be discriminated from other high achieving/ability students).

Note:
The forth level, 'very difficult' has been included in the levels of difficulty of examination questions to ensure that there are sufficient questions that discriminate well amongst higher ability candidates.

7.3 Question difficulty is determined against the assumed capabilities of the ideal 'envisaged' Grade 12 Mechanical Technology NSC examination candidate

The revised Umalusi NSC examination evaluation instruments require evaluators to exercise expert judgments about whether each examination question is 'Easy', 'Moderately challenging', 'Difficult' or 'Very difficult' for the '**envisaged**' Grade 12 learner to answer (Table 5). In other words, assessment of question difficulty is linked to a particular target student within the population of NSC candidates, that is, the Grade 12 candidate of average intelligence or ability.

The Grade 12 learners that you may have taught over the course of your career cannot be used as a benchmark of the 'envisaged' candidate as we cannot know whether their abilities fall too high, or too low on the entire spectrum of

all Grade 12 Mechanical Technology candidates in South Africa. The revised Umalusi NSC examination evaluation instruments thus emphasise that, when rating the level of difficulty of a particular question, your conception of the 'envisaged' candidate needs to be representative of the entire population of candidates for all schools in the country, in other words, of the overall Grade 12 population.

Most importantly, the conception of this 'envisaged' candidate is a learner who has been taught the whole curriculum adequately by a teacher who is qualified to teach the subject, in a functioning school. There are many disparities in the South African education system that can lead to very large differences in the implementation of the curriculum. Thus this 'envisaged' learner is not a typical South African Grade 12 learner – it an intellectual construct (an imagined person) whom you need to imagine when judging the level of difficulty of a question. This ideal 'envisaged' Grade 12 learner is an aspirational ideal of where we would like all Mechanical Technology learners in South Africa to be.

Note:
The concept of the ***ideal envisaged Grade 12 candidate is*** that of an imaginary learner who has the following features:

a. Is of average intelligence or ability
b. Has been taught by a competent teacher
c. Has been exposed to the entire examinable curriculum

This envisaged learner represents an imaginary person who occupies the middle ground of ability and approaches questions *having had all the necessary schooling.*

7.4 Question difficulty is determined using a common framework for thinking about question difficulty

Examiners, moderators and evaluators **in all subjects** are now provided with a common framework for thinking about question difficulty to use when identifying sources of difficulty or ease in each question, and to provide their reasons for the level of difficulty they select for each examination question.

The framework described in detail below provides the main sources of difficulty or 'ease' inherent in questions. The four sources of difficulty which must be considered when thinking about the level of difficulty of examination questions in this framework are as follows:

1. '**Content difficulty** 'refers to the difficulty inherent in the subject matter and/or concept/s assessed.
2. '**Stimulus difficulty'** refers to the difficulty that candidates confront when they attempt to read and understand the question and its source material. The demands of the reading required to answer a question thus forms an important element of 'stimulus difficulty'.
3. '**Task difficulty'** refers to the difficulty that candidates confront when they try to formulate or produce an answer. The level of cognitive demand of a question forms an element of 'Task difficulty', as does the demand of the written text or representations that learners are required to produce for their response.
4. **'Expected response difficulty'** refers to difficulty imposed by examiners in a marking guideline, scoring rubric or memorandum. For example, mark allocations affect the amount and level of answers students are expected to write.

This framework derived from Leong (2006) was chosen because it allows the person making judgments about question difficulty to grapple with nuances and with making connections. The underlying assumption is that judgment of question difficulty is influenced by the interaction and overlap of different aspects of the four main sources of difficulty. Whilst one of the above four sources of difficulty may be more pronounced in a specific question, the other three sources may also be evident. Furthermore, not all four sources of difficulty need to be present for a question to be rated as difficult.

The four-category conceptual framework is part of the required Umalusi examination evaluation instruments. Each category or source of difficulty in this framework is described and explained in detail below (Table 6). Please read the entire table very carefully.

TABLE 6: FRAMEWORK FOR THINKING ABOUT QUESTION DIFFICULTY

CONTENT/CONCEPT DIFFICULTY
Content/concept difficulty indexes the difficulty in the **subject matter, topic or conceptual knowledge** assessed or required. In this judgment of the item/question, difficulty exists in the **academic and conceptual demands** that questions make and/or the **grade level** boundaries of the various 'elements' of domain/subject knowledge (topics, facts, concepts, principles and procedures associated with the subject).
For example:
Questions that assess '**advanced content'**, that is, subject knowledge that is considered to be in advance of the grade level curriculum, are *likely* to be difficult or very difficult for most candidates. Questions that assess subject knowledge which forms part of the core curriculum for the grade are *likely* to be moderately difficult for most candidates. Questions that assess **'basic content'** or subject knowledge candidates would have learnt at lower grade levels, and which would be familiar to them are *unlikely* to pose too much of a challenge to most candidates. Questions that require general everyday knowledge or knowledge of 'real life' experiences are *often* easier than those that test more **specialized** school **knowledge**. Questions involving only concrete objects, phenomena, or processes are *usually* easier than those that involve more **abstract constructs, ideas, processes or modes.** Questions which test learners' understanding of theoretical or **de-contextualised issues or topics**, rather than their knowledge of specific examples or contextualised topics or issues *tend* to be more difficult. Questions involving familiar, contemporary/current contexts or events are *usually* easier than those that are more **abstract or** involve **'imagined' events** (e.g. past/future events) or **contexts** that are **distant from learners' experiences.** Content difficulty may also be varied by changing **the number of knowledge elements or operations assessed**. *Generally,* the difficulty of a question increases with the number of knowledge elements or operations assessed. Questions that assess learners on two or more knowledge elements or operations are *usually* (but not always) more difficult than those that assess a single knowledge element or operation. Assessing learners on **a combination of knowledge elements or operations that are seldom combined** *usually* increases the level of difficulty.
EXAMPLES OF INVALID OR UNINTENDED SOURCE OF CONTENT DIFFICULTY
• Testing obscure or unimportant concepts or facts that are not mentioned in the curriculum, or which are unimportant to the curriculum learning objectives. • Testing very advanced concepts or operations that candidates are extremely unlikely to have had opportunities to learn.

STIMULUS DIFFICULTY

Stimulus difficulty refers to the difficulty of the linguistic **features of the question** (**linguistic** complexity) and the challenge that candidates face when they attempt to read, interpret and understand the words and phrases in the question AND when they attempt to read and understand the **information or 'text' or source material (diagrams, tables and graphs, pictures, cartoons, passages, etc.) that accompanies the question.**

For example:

Questions that contain words and phrases that require only simple and straightforward comprehension are *usually* easier than those that require the candidate to understand **subject specific phraseology and terminology** (e.g. idiomatic or grammatical language not usually encountered in everyday language), or that require more technical comprehension and specialised command of words and language (e.g. everyday words involving different meanings within the context of the subject).

Questions that contain information that is 'tailored' to an expected response, that is, questions that contain no irrelevant or distracting information, are *generally* easier than those that require candidates to select relevant and appropriate information or **unpack a large amount of information** for their response. A question **set in a very rich context** *can* increase question difficulty. For example, learners *may* find it difficult to select the correct operation when, for example, a mathematics or accountancy question is set in a context-rich context.

Although the level of difficulty in examinations is *usually* revealed most clearly through the questions, text complexity or the degree of **challenge or complexity in written or graphic texts** (such as a graph, table, picture, cartoon, etc.) that learners are required to read and interpret in order to respond *can* increase the level of difficulty. Questions that depend on reading and selecting content from a text *can* be more challenging than questions that do not **depend on actually reading the accompanying text** because they test reading comprehension skills as well as subject knowledge. Questions that require candidates to **read a lot** *can* be more challenging than those that require limited reading. Questions that tell learners where in the text to look for relevant information are *usually* easier than those where **learners are not told where to look**.

The level of difficulty *may* increase if texts set, and reading passages or other **source material** used are challenging for the grade level, and make **high reading demands** on learners at the grade level. Predictors of textual difficulty include:

- **semantic content** – for example, if vocabulary and words used are typically outside the reading vocabulary of Grade 12 learners, 'texts' (passage, cartoon, diagram, table, etc.) are *usually* more difficult. 'Texts' are *generally* easier if words or images are made accessible by using semantic/context, syntactic/structural or graphophonic/visual cues.
- **syntactic or organisational structure** – for example, sentence structure and length. For example, if learners are likely to be *familiar with the structure* of

the 'text' or resource, for example, from reading newspapers or magazines, etc. 'texts' are *usually* easier than when the structure is unfamiliar.
- **literary techniques** – for example, abstractness of ideas and imagery – and **background knowledge required**, for example, to make sense of allusions.
- if the **context** is **unfamiliar** or remote, or if candidates do not have or are **not provided with access to the context** which informs a text (source material, passage, diagram, table, etc.) they are expected to read, and which informs the question they are supposed to answer and the answer they are expected to write, then constructing a response is *likely* to be more difficult than when the context is provided or familiar.

Questions which require learners to **cross-reference different sources** are *usually* more difficult than those which deal with one source at a time.

Another factor in stimulus difficulty is presentation and visual appearance. For example, type face and size, use of headings, and other types of textual organisers etc. can aid **'readability'** and make it easier for learners to interpret the meaning of a question.

EXAMPLES OF INVALID OR UNINTENDED SOURCES OF STIMULUS DIFFICULTY

- Meaning of words unclear or unknown.
- Difficult or impossible to work out what the question is asking.
- Questions which are ambiguous.
- Grammatical errors in the question that could cause misunderstanding.
- Inaccuracy or inconsistency of information or data given.
- Insufficient information provided.
- Unclear resource (badly drawn or printed diagram, inappropriate graph, unconventional table).
- Dense presentation (too many important points packed in a certain part of the stimulus).

TASK DIFFICULTY

Task difficulty refers to the **difficulty that candidates confront when they try to formulate or produce an answer**.

For example:

In most questions, to generate a response, candidates have to work through the steps of a solution. *Generally*, questions that **require more steps in a solution** are more difficult than those that require fewer steps. Questions involving only one or two steps in the solution are *generally* easier than those where several operations required for a solution**.**

Task difficulty may also be mediated by the **amount of guidance present in the question**. Although question format is not necessarily a factor and difficult questions can have a short or simple format, questions that provide guided steps or cues (e.g. a clear and detailed framework for answering) are *generally* easier than those that are more open ended and require candidates to form or tailor their **own response strategy** or argument, work out the steps **and maintain the**

strategy for answering the question by themselves. A high degree of prompting (a high degree of prompted recall, for example) *tends* to reduce difficulty level.

Questions that test specific knowledge are *usually* less difficult that **multi-step, multiple-concept or operation questions**.

A question that requires the candidate to **use** a **high level of** appropriate **subject specific, scientific or specialised terminology in** their **response** *tends* to be more difficult than one which does not.

A question requiring candidates to **create a complex abstract (symbolic or graphic) representation** is *usually* more challenging than a question requiring candidates to create a concrete representation.

A question requiring writing a one-word answer, a phrase, or a simple sentence is *often* easier to write than **responses that require more complex sentences, a paragraph or a full essay or composition**.

Narrative or descriptive writing, for example where the focus is on recounting or ordering a sequence of events chronologically, is *usually* easier than **writing discursively** (**argumentatively or analytically**) where ideas need to be developed and ordered logically. Some questions reflect task difficulty simply by **'creating the space' for A-Grade candidates** to demonstrate genuine insight, original thought or good argumentation, and to write succinctly and coherently about their knowledge.

Another element is the **complexity in structure of the required response**. When simple connections between ideas or operations are expected in a response, the question is *generally* easier to answer than a question in which the significance of the relations between the parts and the whole is expected to be discussed in a response. In other words, a question in which an unstructured response is expected is *generally* easier than a question in which **a relational response** is required. A response which involves **combining or linking a number of complex ideas or operations** is *usually* more difficult than a response where there is no need to combine or link ideas or operations.

On the other hand, questions which require continuous prose or extended writing *may* also be easier to answer correctly or to get marks for than questions that require no writing at all or single letter answer (such as multiple choice), or a brief response of one or two words or short phrase/s because they **test very specific knowledge**.

The **cognitive demand** or **thinking processes** required form an aspect of task difficulty. Some questions test thinking ability, and learners' capacity to deal with ideas, etc. Questions that assess inferential comprehension or application of knowledge, or that require learners to take ideas from one context and use it in another, for example, *tend* to be more difficult than questions that assess recognition or retrieval of basic information. On the other hand, questions requiring recall of knowledge are *usually* more difficult than questions that require simple recognition processes.

When the **resources for answering** the question are included in the examination paper, then the task is *usually* easier than when candidates have to **use and select their own internal resources** (for example, their own knowledge of the subject) or transform information to answer the question.

Questions that require learners to take or **transfer** ideas, **skills or knowledge from one context/subject area and use them in another** *tend* to be more difficult.

EXAMPLES OF INVALID OR UNINTENDED SOURCES OF TASK DIFFICULTY

- Level of detail required in an answer is unclear.
- Context is unrelated to or uncharacteristic of the task than candidates have to do.
- Details of a context distract candidates from recalling or using the right bits of their knowledge.
- Question is unanswerable.
- Illogical order or sequence of parts of the questions.
- Interference from a previous question.
- Insufficient space (or time) allocated for responding.
- Question predictability or task familiarity. If the same question regularly appears in examination papers or has been provided to schools as exemplars, learners are likely to have had prior exposure, and practised and rehearsed answers in class (for example, when the same language set works are prescribed each year).
- Questions which involve potential follow-on errors from answers to previous questions.

EXPECTED RESPONSE DIFFICULTY

Expected response difficulty refers to difficulty imposed by examiners in a **mark scheme and memorandum**. This location of difficulty is more applicable to 'constructed' response questions, as opposed to 'selected' response questions (such as multiple choice, matching/true-false).

For example:

When examiners expect few or no details in a response, the question is *generally* easier than one where the mark scheme implies that **a lot of details are expected**.

A further aspect of expected response difficulty is the clarity of the **allocation of marks**. Questions are *generally* easier when the allocation of marks is explicit, straight-forward or logical (i.e. 3 marks for listing 3 points) than when the **mark allocation is indeterminate or implicit** (e.g. when candidates need all 3 points for one full mark or 20 marks for a discussion of a concept, without any indication of how much and what to write in a response). This aspect affects difficulty because candidates who are unclear about the mark expectations in a response may not produce sufficient amount of answers in their response that will earn the marks that befit their ability.

Some questions are more difficult/easy to mark accurately than others. Questions that are **harder to mark and score objectively** are *generally* more difficult for

candidates than questions that require simple marking or scoring strategies on the part of markers. For example, recognition and recall questions are *usually* easier to test and mark objectively because they usually require the use of matching and/or simple scanning strategies on the part of markers. More complex questions requiring analysis (breaking down a passage or material into its component parts), evaluation (making judgments, for example, about the worth of material or text, or about solutions to a problem), synthesis (bringing together parts or elements to form a whole), and creativity (presenting own ideas or original thoughts) are *generally* harder to mark/score objectively. The best way to test for analysis, evaluation, synthesis and creativity is usually through extended writing. Such extended writing *generally* requires the use of more cognitively demanding *marking* strategies such as interpreting and evaluating the logic of what the candidate has written.

Questions where **a wide range of alternative answers or response/s** is possible or where the correct answer may be arrived at through different strategies *tend* to be more difficult. On the other hand, questions may be so open-ended that learners will get marks even if they engage with the task very superficially.

EXAMPLES OF INVALID OR UNINTENDED SOURCES OF EXPECTED RESPONSE DIFFICULTY

- Mark allocation is unclear or illogical. The weighting of marks is important in questions that comprise more than one component when components vary in levels of difficulty. Learners may be able to get the same marks for answering easy component/s of the item as other learners are awarded for answering the more difficult components.
- Mark scheme and questions are incongruent. For example, there is no clear correlation between the mark indicated on the question paper and the mark allocation of the memorandum.
- Question asked is not the one that examiners want candidates to answer. Memorandum spells out expectation to a slightly different question, not the actual question.
- Impossible for candidate to work out from the question what the answer to the question is (answer is indeterminable).
- Wrong answer provided in memorandum.
- Alternative correct answers from those provided or spelt out in the memorandum are also plausible.
- The question is 'open' but the memo has a closed response. Memo allows no leeway for markers to interpret answers and give credit where due.

The framework described above does not provide you with explicit links between the different sources of difficulty, or show relationships and overlaps between the different categories and concepts in the framework. This is because it is impossible to set prescribed rules or pre-determined combinations

of categories and concepts used for making judgments about the source of difficulty in a particular examination question.

The intention behind the framework is to allow you to exercise your sense of judgment as an expert. The complexity of your judgment lies in your ability as an expert to recognise subtle interactions and identify links between different categories of a question's difficulty or ease. For example, a question that tests specific knowledge of your subject can actually be more difficult that a multi-step question because it requires candidates to explain a highly abstract concept, or very complex content. In other words, although questions that test specific knowledge are *usually* less difficult than multiple-concept or operation questions, the level of difficulty of the content knowledge required to answer a question can make the question more difficult than a multi-step or multi-operation question.

Not all one-word response questions can automatically be assumed to be easy. For example, multiple-choice questions are not automatically easy because a choice of responses is provided – some can be difficult. As an expert in your subject, you need to make these types of judgments about each question.

Note:
It is very important that you become extremely familiar with the framework explained in Table 6, and with each category or source of difficulty provided (i.e. content difficulty, task difficulty, stimulus difficulty, and expected response difficulty). You need to understand the examples of questions which illustrate each of the four levels (Table 7 to Table 10). This framework is intended to assist you in discussing and justifying your decisions regarding the difficulty level ratings of questions. You are expected to **refer to all four categories or sources of difficulty** in justifying your decisions.

When considering question difficulty ask:

- How difficult is the **knowledge** (content, concepts or procedures) that is being assessed for the envisaged Grade 12 candidate? (*Content difficulty*)
- How difficult is it for the envisaged I Grade 12 candidate to formulate the answer to the question? In considering this source of difficulty, you should **take into account the type of cognitive demand** made by the task. (*Task difficulty*)
- How difficult is it for the envisaged Grade 12 candidate to **understand the question and the source material** that need to be read to answer the particular question? (*Stimulus difficulty*)
- What does the **marking memorandum and mark scheme** show about the difficulty of the question? (*Expected response difficulty*)

7.5 Question difficulty entails distinguishing unintended sources of difficulty or ease from intended sources of difficulty or ease

Close inspection of the framework for thinking about question difficulty (Section 7.4, Table 6) above, shows that, for each general category or source of difficulty, the framework makes a distinction between 'valid' or intended, and 'invalid' or unintended sources of question difficulty or ease. Therefore, defining question difficulty entails identifying whether sources of difficulty or ease in a question were intended or unintended by examiners. Included in Table 6 are examples of unintended sources of difficulty or ease for each of the four categories.

Valid difficulty or 'easiness' in a question has its source in the requirements of the question, and is ***intended*** by the examiner (Ahmed and Pollit, 1999). Invalid sources of difficulty or 'easiness' refer to those features of question difficulty or 'easiness' that were ***not intended*** by the examiner. Such unintended 'mistakes' or omissions in questions can prevent the question from assessing what the examiner intended, and are likely to prevent candidates from demonstrating their true ability or competence, and can result in a question being easier or more difficult than the examiner intended.

For example, grammatical errors in a question that could cause misunderstanding for candidates are unintended sources of question difficulty because the difficulty in answering the question could lie in the faulty formulation of the question, rather than in the intrinsic difficulty of the question itself (for example, because of stimulus difficulty). Candidates "may misunderstand the question and therefore not be able to demonstrate what they know" (Ahmed and Pollit, 1999, p.2). Another example is question predictability (when the same questions regularly appear in examination papers or textbooks) because familiarity can make a question which was intended to be difficult, less challenging for examination candidates.

Detecting unintended sources of difficulty or ease in examinations is largely the task of moderators. Nevertheless, evaluators also need to be vigilant about

detecting sources which could influence or alter the intended level of question difficulty that moderators may have overlooked.

Note:
When judging question difficulty, you should distinguish **unintended sources of question difficulty or ease** from those sources that are intended, thus ensuring that examinations have a range of levels of difficulty. The framework for thinking about question difficulty allows you to systematically identify technical and other problems in each question. Examples of problems might be: unclear instructions, poor phrasing of questions, the provision of inaccurate and insufficient information, unclear or confusing visual sources or illustrations, incorrect use of terminology, inaccurate or inadequate answers in the marking memorandum, and question predictability. You should **not** rate a question as difficult/easy if the source of difficulty/ease lies in the 'faultiness' of the question or memorandum. Instead, as moderators and evaluators, you need to alert examiners to unintended sources of difficulty/ease so that they can improve questions and remedy errors or sources of confusion before candidates write the examination.

7.6 Question difficulty entails identifying differences in levels of difficulty within a single question

An examination question can incorporate more than one level of difficulty if it has subsections. It is important that the components of such questions are 'broken down' into to their individual levels of difficulty.

Note:
Each subsection of a question should be analysed separately so that the percentage of marks allocated at each level of difficulty and the weighting for each level of difficulty can be ascertained as accurately as possible for that question.

8. EXAMPLES OF QUESTIONS AT DIFFERENT LEVELS OF DIFFICULTY

This section provides at least **three** examples of questions from previous Mechanical Technology NSC examinations (Table 7 to Table 10) categorised at each of the four levels of difficulty described in Section 7 (Table 5) above. These examples were selected to represent the **best and clearest** examples of each level of difficulty that the Mechanical Technology experts could find. The

discussion below each example question tries to explain the reasoning behind the judgments made about the categorisation of the question at that particular level of difficulty.

TABLE 7: EXAMPLES OF QUESTIONS AT DIFFICULTY LEVEL 1 – EASY

Example 1:
Question 4.7 Nov 2009, DBE What does the abbreviation PVC stand for? (1)
This question is categorised as easy because: • To answer this question, candidates require basic knowledge of materials used in mechanical technology. Candidates should know the abbreviation PVC and what it stands for. The envisaged Grade 12 candidate should be very familiar with this abbreviation as it is common practice for abbreviations to be used in mechanical technology **(content)**. • The question is easy to understand and the requirements are very explicit. It is clearly phrased with no hidden aspects. The term 'abbreviation' is an 'everyday' term which should be familiar to all Grade 12 candidates as it is also used in other subjects **(stimulus)**. • Candidates need to recall what each letter (PVC) stands for. They simply have to remember what they were taught in class, from textbooks, other resource material and during practical work. They don't have to show understanding by providing any explanation **(task)**. • The marking scheme is straight forward, candidates get one mark for correctly writing down what the abbreviation. The envisaged Grade 12 candidate should find it easy to achieve full marks. The answer is short and simple and easy to mark **(expected response)**. This question is categorized as easy for the envisaged Grade 12 candidate in relation to all four possible sources of difficulty outlined in the framework.
Memorandum/Marking guidelines • Polyvinyl chloride ✓(1)
Example 2:
Question 2.4.2 Nov 2011, DBE Name two gases used in MAGS/ MIGS welding. (2)
Discussion: • The question itself is clear and easy to read and understand. The instructions are very specific – candidates have to name only TWO gases. The abbreviations used in the question, MAGS/MIGS, refer to Metal arc gas shielded (MAGS) and Metal inert gas shielded (MIGS) and should both be familiar to all Grade 12 candidates **(stimulus)**.

- The task involves remembering the names of two gases used during the MAGS/MIGS, namely, argon and helium. Candidates have to recall what they have learnt in the classroom, from their textbooks and during their practical work. Candidates need to name the two gases **(task)**.
- Candidates get one mark each for correctly stating the names of each of the gases used. The answers are easy to mark as they consist of two words. The mark allocation is one each and marking is straightforward **(expected response)**.
- To answer the question candidates need to know the names of the special gases used during the advanced welding process, MIGS/MAGS. The envisaged Grade 12 candidates should have learnt this information on MIG/MAGS welding in the class room, from manuals, the Grade 12 Mechanical Technology textbooks and during their practical work. What makes the content easy is that the MAGS/MIGS welding process is familiar to the Grade 12 candidate and is used during the practical assessment task **(content).**

The question is thus categorized easy with regard to 3 sources of difficulty: task, stimuli and expected response?

Memorandum/Marking guidelines

- Argon ✓(2)
- $C0_2$ ✓
- Helium ✓

(Any 2 x 1)

Example 3:

Question 2.5 Nov 2014, DBE

What is the maximum distance that the tool rest should be set from the grinding wheel of a bench grinder? (1)

Discussion:

This question is classified as a low order cognitive level question in terms cognitive demand. It is categorised as easy in terms of level of difficulty because:

- The question is easy to read and understand. The requirements are very explicit. The Grade 12 candidates should be familiar with the Bench grinding machine. This machine is extensively used in the mechanical technology workshop from Grade 10 up until Grade 12 **(stimulus)**.
- In mechanical technology, it is necessary to use the bench grinding machine when working with the practical assessment task and when sharpening tools. All Grade 12 candidates should be familiar with this machine. They should all have learnt about this machine and the distance the tool rest should be from the grinding wheel in the class room and during their practical work. The envisaged Grade 12 candidate should find it easy to understand this question **(content)**.
- To answer the question, candidates need to recall the maximum distance the tool rest should be from the grinding wheel. The envisaged Grade 12 candidate should find this question easy **(task)**.
- Candidates get one mark for correctly answering this question. The envisaged Grade 12 candidate should easily answer this question **(expected response)**.

The question is easy, in terms of all four possible sources of difficulty.
Memorandum/Marking guidelines 3 mm ✓ (1)

TABLE 8: EXAMPLES OF QUESTIONS AT DIFFICULTY LEVEL 2 – MODERATE

Example 1:
Question 6.2 Nov 2014, DBE Explain the procedure followed during a nick break test on a welded joint. (5)
Discussion: This question is categorised as moderately difficult in terms of level of difficulty because: • The question is easy to read and understand. The requirements are very explicit. The Grade 12 candidates should explain the procedure how a 'nick break test' is done on a welded joint **(stimulus)**. • In mechanical technology, it is necessary to conduct various tests on welded joints to check for defects. Grade 12 candidates should all have learnt about the two main classes of tests that can be performed on welded joints, namely destructive and non- destructive tests. Answering this question requires step by step how a nick break test is performed on a welded joint. The Grade 12 candidates should all have learnt about this test process in the classroom and during their practical work. The envisaged Grade 12 candidate should find this question moderately difficult to answer **(content)**. • To answer the question, candidates need to explain step by step how a nick break test is performed on a welded joint. The envisaged Grade 12 candidate should find this procedure moderately difficult **(task)**. • Candidates get five marks for correctly answering this question. According to the memorandum, one mark is allocated for each correct step stated **(expected response)**. The question is moderately difficult in terms of all four possible sources of difficulty.
Memorandum/Marking guidelines Nick break test: (5) • Each edge of the weld is slotted by means of a saw. ✓ • Place the specimen on two steel supports. ✓ • Use a hammer to break the specimen by striking it in the zone where the cut was made. ✓ • The weld metal exposed should be completely fused, free from slag inclusions and contain no gas pockets greater than 1,6 mm. ✓ • There should not be more than one pore or gas pocket per square centimetre. ✓

Example 2:

Question 5.7.2 Nov 2013, DBE

Explain the operation of a turbocharger. (6)

Discussion:

This question is moderately difficult in terms of level of difficulty because:

- This question is straight forward and easy to read. The requirements are very explicit; candidates must explain how a turbocharger works. Grade 12 candidates should be familiar with the term 'turbocharger'**(stimulus)**.
- To answer this question candidates need to know how a turbocharger works. Grade 12 candidates should have learnt about turbochargers in the classroom, from textbooks and from other resource material. Underpinning the working principles of a turbocharger involves abstract explanation and understanding therefore this question is considered moderately difficult for the envisaged Grade 12 candidate **(content)**.
- To answer this question, candidates need to step by step how a turbocharger operates. The envisaged Grade 12 candidate should find this question moderately difficult **(task)**.
- Six marks are allocated for this question. One mark is awarded for each correct phase of the operation. Although the question does not specify the number of phases that need to be provided, the envisaged Grade 12 candidate should easily work this out from the number of marks allocated. The envisaged Grade 12 candidate should find this question moderately difficult **(expected response)**.

The question is moderately difficult in terms of all four possible sources of difficulty.

Memorandum/Marking guidelines

Operation of the turbocharger:

- The exhaust gases from the engine is routed to the turbine wheel to enable the turbine wheel to spin at very high speed. ✓
- The gases are then channelled out of the housing and wheel assembly into the normal exhaust system. ✓
- As the turbine wheel spins, it turns a common shaft, which in turn spins the compressor wheel. ✓
- The compressor draws air or air and fuel mixture in through the compressor inlet. ✓
- The compressor compresses and delivers the compressed air through the output and the induction passage then into the cylinders. ✓
- This boosted pressure delivered to the cylinders increases the volumetric efficiency of the engine as well as the engine performance.✓

(6)

Example 3:

Question 3.2 Nov 2008, DBE

Ms Bonga has a fifteen - seater minibus, which she uses daily to transport Learner's to school and back. Recently she found that the power of the vehicle has decreased. Compare the different causes of pressure drop during a compression test in relation to how these leakages could be traced. (10)

Discussion:

This question is categorised as moderately difficult because:

- This question analyses the two types of tests that are done on a motor vehicle, namely a compression test and a pressure test. Candidates must know the different causes of pressure drop in a motor vehicle, the causes of loss in engine power and how these leakages could be traced in a motor vehicle. Candidates must apply their knowledge and skills on four stroke engines to answer this question. Candidates must use specialized advanced testing tools, to determine the cause of power loss in the engine. Candidates are required to compare findings. They have to know that for each fault presented there is a unique cause. A special test is done to identify the different problems. Candidates should have learnt this in classroom and during the practical assessment task. This question is a moderately difficult question for the envisaged Grade 12 candidate **(content)**.
- The question itself is easy to understand. The words used are simple and straight forward. The source material is straight forward comprehension but contain important information that candidates need to work from. Fault finding is a unique skill that makes the question challenging and moderately difficult for the envisaged Grade 12 candidate **(stimulus)**.
- To answer this question, candidates need to compare the different causes of loss in power in the engine. They also have to identify the fault, determine the cause and must trace its source by performing certain tests. Candidates must apply both their theoretically knowledge as well as their practical experience to answer this question. Candidates could write their answers in table format. A large amount of information must be recalled, to answer this question, which makes this task challenging for the envisaged Grade 12 candidates to answer **(task)**.
- Ten marks are allocated to this question. Five marks are allocated for identify the cause of power loss and five marks for correctly identify the area were power loss occur. In order for the answer to be marked correct the cause and area must be related **(expected response)**.

The question is moderately difficult in terms of all four possible sources of difficulty.

Memorandum/Marking guidelines

Causes of pressure drop	How leakages are traced.
Listen at the carburettor for a hissing noise ✓	Inlet valve is leaking ✓
Listen at the exhaust pipe for a hissing noise ✓	Exhaust valve is leaking ✓
Listen for a hissing noise in the dipstick hole ✓	Piston ring is worn ✓
Remove the filler cap on the tappet cover and listen for a hissing noise ✓	Rings are worn ✓
If you see bubbles in the radiator water ✓	The cylinder head gasket is blown ✓

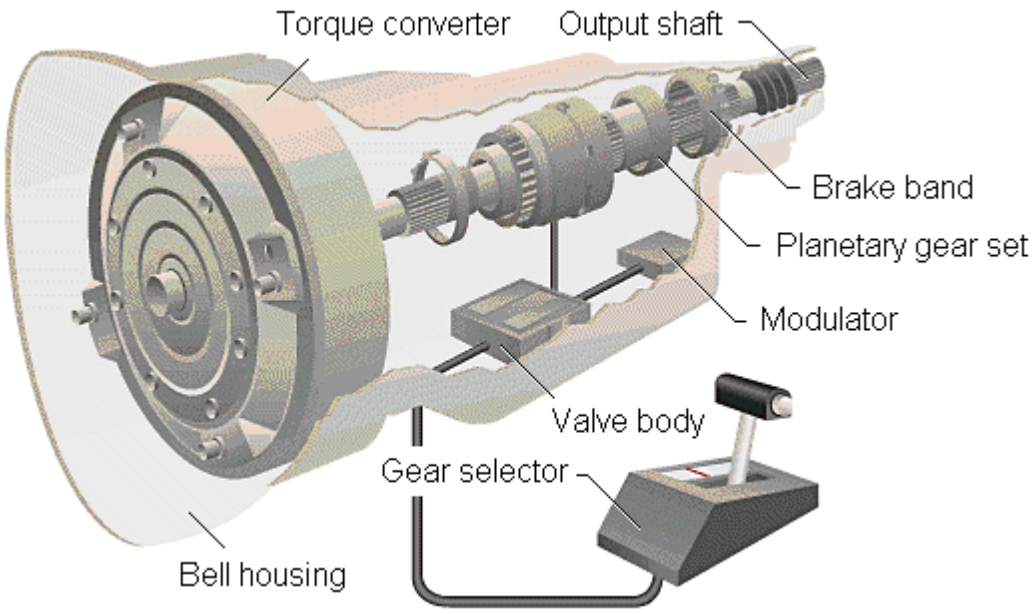
(10)

TABLE 9: EXAMPLES OF QUESTIONS AT DIFFICULTY LEVEL 3 – DIFFICULT

Example 1:

Question 5.7 Nov 2008, DBE

Gear cutting



Manuel is a taxi owner and he has a problem with the taxi's gearbox. When the mechanics stripped the gearbox, they found that one of the gears was broken.

You are required to manufacture a replacement gear. The gear has103 teeth.

2.7.1 Calculate the simple indexing.
(Hint: Use 100 divisions for the simple indexing.) (3)

5.7.2 Calculate the change gears for the dividing head. (6)

Discussion:

This question is categorised as difficult because:

- The diagram shown is a sectional view of a gear box. This could be misleading because candidates could focus on the gear box, instead of paying attention on the calculations of simple indexing and change gears. The sub-questions are easy for the envisaged Grade 12 candidate to read and understand. The terms/phrases 'simple indexing'; 'change gears' and 'dividing head' should be familiar to the envisaged Grade 12 candidate **(stimulus)**.
- The task in Question 5.7 is to manufacture a replacement gear which has 103 teeth. Candidates must first calculate the simple indexing and the required change gears to cut the gear. This process makes the task difficult. They must

make sure that their sub-answer is written in fraction format and not as a decimal. This will enable them to calculate their final answer using the correct index plate and hole size **(task)**.

- To answer these sub-questions, candidates need to calculate simple indexing to cut a gear of 103 teeth and calculate the change gears. These calculations should be familiar to the envisaged Grade 12 candidates. They should have learnt this in the classroom and during their practical assessment task **(content)**.
- Nine marks are allocated for this question. Three marks are allocated to sub-question 5.7.1 for correctly calculating simple indexing and six marks are allocated in sub-question 5.7.2 for correctly calculating the required change gears. There is no margin for error when answering these questions. If the first step of the calculation is incorrect, the rest of the answer is marked wrong because the incorrect gear would have been cut. This aspect makes the expected response difficult for the envisaged Grade 12 candidate **(expected response)**.

The question is difficult in terms of all four possible sources of difficulty.

Memorandum/Marking guidelines

INDEXING

HOLE CIRCLES
Side 1 - 24 ,25, 28, 30, 34 ,37, 38, 39, 41 ,42 ,43
Side 2 - 46 ,47 ,49 ,51 ,53, 54 ,57, 58, 59, 62 ,66

STANDARD CHANGE GEARS
24 x2, 28 ,32 ,40 ,44, 48, 56 ,64, 72, 86, 100

Simple Indexing (use N = 100)

Indexing = $\frac{40}{N}$

$= \frac{40}{100}$ ✓

$= \frac{2 \times 5}{5 \quad 5 \quad 25} = \frac{10}{}$ ✓

No full turns and 10 holes on a 25-hole circle ✓(3)

Change Gear = $\frac{Dr}{Dv} = \frac{(N - n) \times 40}{N}$ ✓

$= \frac{(100 - 103) \times 40}{100}$ ✓

$= -\frac{120}{}$ ✓

100

= - 6 x 8 ✓

5 8

= - 48 ✓

40

In the opposite direction of the crank ✓

(6)

Example 2:

(Example formulated by subject expert for the purpose of this manual)

You are a designer and it is required of you to use various alloys in your projects. Compare the compositions and properties of the following non-ferrous alloys:

a) Aluminium bronze
b) Duralumin

(2x2=4 mark)

Discussion:

This question is categorised as difficult because:

- Various types of materials are used in mechanical technology. These materials have extremely high load carrying capacity and have different properties. The envisaged Grade 12 candidates should have learnt about these materials in the classroom and from reading their Mechanical Technology textbooks as well as from other relevant manuals and videos. To answer this question, candidates must compare the composition and the properties of each of the two non – ferrous alloys namely Aluminium bronze and Duralumin **(content)**.
- The question is clear and easy for the envisaged Grade 12 candidates to read and understand. Candidates must also use prior knowledge to answer this question. The instructions are specific. Candidates need to determine the alloy elements, compare them and mention their relative properties. The term used should be familiar to the envisaged Grade12 candidate **(stimulus)**.
- To answer this question, candidates need to recall substantial amount of information on the different types of materials. Candidates must identify the alloy element, compare their composition and then state their relative properties. Candidates must also apply prior knowledge to answer this question. Complex information is used to answer this question, and makes it challenging for the envisaged Grade 12 candidate **(task)**.
- Four marks are allocated to this question. Responses will comprise two alloys and two properties tabulated. The mark allocation and marking is therefore straight forward **(expected response)**.

The question is difficult in terms of all four possible sources of difficulty.

Memorandum/Marking guidelines

Alloy	Composition	Properties
Aluminium Bronze	Consists of copper and aluminium ✓	Any one of the following: • Ductile ✓ • Malleable ✓ • Corrosion resistant ✓ • Tough ✓ • Hard ✓ (Any 1 answer)
Duralumin	Consists of copper and Manganese, magnesium and aluminium ✓	Any one of the following: • Very strong ✓ • Light ✓ • Hardens with age✓ (Any 1 answer)

(4)

Example 3:

Question 3:

(Example formulated by subject expert for the purpose of this manual).

A mechanical technologist is required to design a compound gear train for a tool making machine. The input shaft is dissipating 5 kW of power at a speed of 840 Rpm. The customer requires that the machine produce a minimum torque of 200 Nm at a speed of 200 Rpm.

The following gears must be used to build up the gear train (35 T; 86T; 43T; & 70 T). The gears must be so arranged that when assembled it will form the gear train that will satisfy the customers need.

3.1.1 Sketch and label the gear train (3)
3.1.2 Calculate the actual torque at the output. (3)
3.1.3 Calculate the output speed (4)
3.1.4 Is the gear train suitable for the customer? Motivate (3)

Discussion:

This question is categorised as difficult because:

- To answer this question, the envisaged Grade 12 candidate must understand how gears are used to obtain specific outcomes namely how speed, torque and power can be increased or decreased using gear drives. Candidates must arrange, formulate and then calculate the required torque and output speed. Candidates are required to compare the findings and motivate if design is suitable or not. This question is difficult for the envisaged Grade 12 learner **(content)**.
- The question is easy to read and understand. The words used are simple and straight forward. The source material does not make high reading demands. The source material contains important information that candidates must use

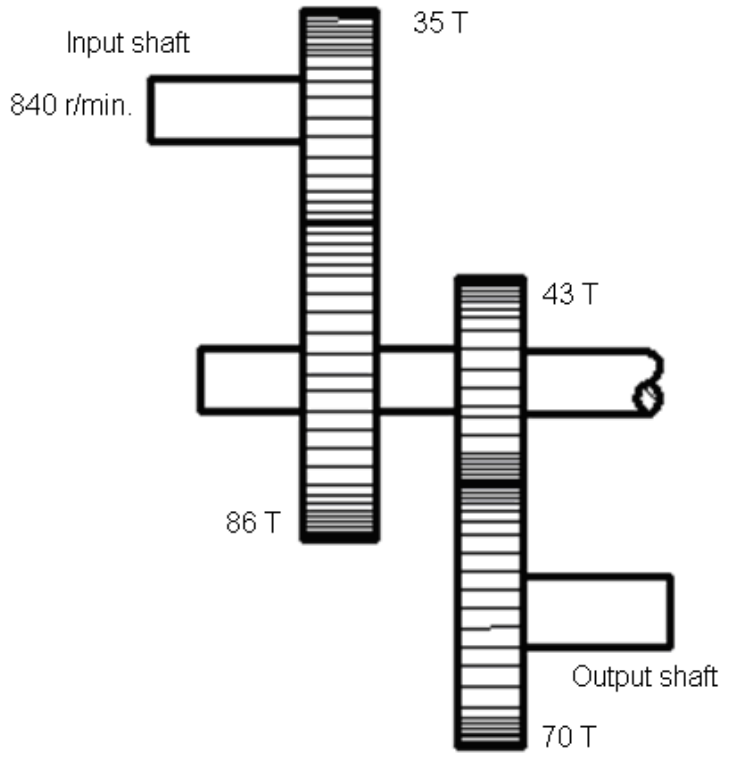
when answering this question. Candidates must recall what they have learnt on system and control. The task will be to sketch and arrange the supplied gears in their correct order that will produce the desired torque and output speed. **(stimulus)**.

- To answer this question, the envisaged Grade 12 candidate need to recall, the different types of gear trains used in mechanical technology. The candidate must sketch the correct gear train using the supplied gears. The incorrect positioning of gears in the gear train and not using the supplied gears, will not produce the desired results. Candidates have to calculate the required torque and output speed. Candidates must apply their theoretically knowledge and practical experience to answer this question. Candidates have to engage in more abstract interpretation and reasoning when answering this question. All information must be considered when answering this question, which makes this task very challenging for the envisaged Grade 12 candidate **(task)**.
- Thirteen marks are allocated to this question. Three marks are allocated for the sketch of the gear train and labelling, this is the first step and a very important step to answer the rest of the question. Incorrect gear selection will not produce the desired outcome. Three marks each for correctly calculating the torque and three marks for calculating the output speed. When marking this question, no method marking is applied should a candidate makes an error in 2.1.2, then 2.1.3 is marked incorrect. Four marks are allocated to motivate if the gear train is suitable or not. One mark is allocated for response and three marks for motivation **(expected response)**.

The question is difficult in terms of all four possible sources of difficulty.

Memorandum/Marking guidelines

3.1.1



(3) ✓✓✓

3.1.2

Power = $\frac{2 \times \pi \times N \times T}{60}$ ✓ (3)

Torque = $\frac{5000 \times 60}{2 \times \pi \times 210}$ ✓

= 227,36 Nm ✓

3.1.3

$\frac{\text{Input speed}}{\text{Output speed}} = \frac{\text{No of teeth on driven gears}}{\text{No of teeth on driven gears}}$ ✓ (4)

Out speed = $\frac{840 \text{ rpm} \times 86 \times 70}{35 \times 43}$ ✓✓

= 210 rpm ✓

3.1.4

Yes, ✓ This gear train is suitable for the customer. It satisfies all the needs that are required for the customer. Both the calculated spindle speed and torque is higher than the desired requirement for this design. ✓✓ ✓ (4)

TABLE 10: EXAMPLE OF A QUESTION AT DIFFICULTY LEVEL 4 – VERY DIFFICULT

Example 1
Question 1: (Example formulated by subject expert for the purpose of this manual) A lever- controlled hydraulic system with specifications is shown diagrammatically in FIGURE 2.1 below. Critically analyse the given data. The load on piston "A" must not exceed 150 kilo Newton, the diameter of piston "B" must be four times the diameter of piston "A". The safe working load necessary to work this lever system must not exceed 900 N. Answer the following questions. 1. Calculate the safe working load (F) that will work this lever system. (12)

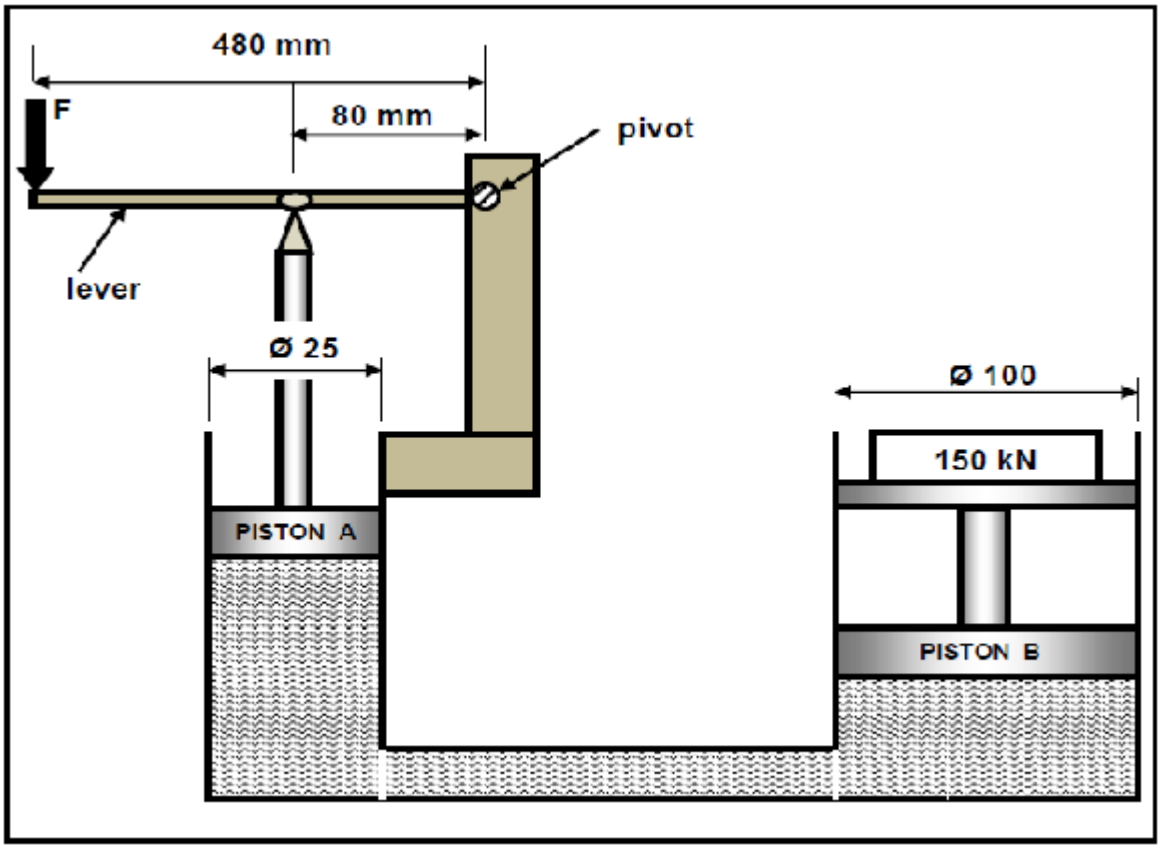


FIGURE 2.1

Discussion:

This question is categorised as very difficult because:

- To answer this question, the envisaged Grade 12 candidate must understand how hydraulic systems work to obtain specific outcomes when calculating area, pressure and force. Thereafter, this information must be used to calculate the force to operate the lever system. Candidates should have learnt about calculations using hydraulics principles in the classroom and from reading their Mechanical Technology textbooks as well as from other relevant manuals and videos. The process includes applying Boyle's law and analysing how the hydraulic principle works. Candidates also have to apply the knowledge of the working principles of a lever operating system **(content)**.
- The question contains information that must be used when answering. The words used are simple and straight forward. The source material contains important information from which the candidates must work. Candidates have to analyse all the information provided in Figure 2.1. They have to also select and synthesise the relevant information to calculate the safe load on the lever system **(stimulus)**.
- To answer this question, candidates must understand how hydraulic system work to obtain specific outcomes when calculating area, pressure and force. Thereafter, this information must be used to calculate the force to operate the lever system. Candidates must apply their theoretically knowledge and practical experience to answer this question. Candidates have to engage in

more abstract interpretation and reasoning when answering this question. This task is very difficult for the envisaged Grade 12 candidate **(task)**.

- Twelve marks are allocated to this question. Two marks allocated for calculating area. Three marks for correctly calculating the pressure and three marks for calculating the force in the hydraulic system. Four marks are allocated for calculating the force of the lever. The mark allocation is clear for markers **(expected response)**.

The question is very difficult in terms of all four possible sources of difficulty.

Memorandum/Marking guidelines Example 1:

2.1.1 **Area B = $\frac{\pi D^2}{4}$** (4)

= $\frac{\pi (0,1)^2}{4}$ ✓

= 7,85 x 10^{-3} m^2 ✓

Pressure = $\frac{\text{Force}_B}{\text{Area}_B}$ ✓

= $\frac{150000}{7,85 \times 10^{-3}\ m^2}$ ✓

= 19,11 MPa ✓

2.1.2 **Area A = $\frac{\pi D^2}{4}$** (4)

= $\frac{\pi (0,025)^2}{4}$

= 0,49 x 10^{-3} m^2

Force A = Pressure x Area_A ✓

= 19,11 MPa x 0,49 x 10^{-3} m^2 ✓

= 9363,9 N ✓

2.1.3 **F x 0,48 = 9363,9 N x 0,08** ✓✓ (4)

F = $\frac{9363,9\ N \times 0,08}{0,48}$ ✓

F = 1560,65 N ✓

9. Concluding remarks

This exemplar book is intended to be used as a training tool to ensure that all role players in the Mechanical Technology Examinations are working from a common set of principles, concepts, tools and frameworks for assessing cognitive challenge when examinations are set, moderated and evaluated. We hope that the discussion provided and the examples of questions shown by level and type of cognitive demand and later by level of difficulty assist users of the exemplar book to achieve this goal.

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