THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY
NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

STUDENTS' ITEM RESPONSE ANALYSIS REPORT ON THE FORM TWO NATIONAL ASSESSMENT (FTNA)2020

ENGINEERING SCIENCE

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035 ENGINEERING SCIENCE

Published by
National Examinations Council of Tanzania,
P.O. Box 2624,
Dar es Salaam, Tanzania.

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FOREWORD

The Students' Item Response Analysis (SIRA) report on the performance of Engineering Science subject for Form Two National Assessment (FTNA) 2020 has been prepared to provide feedback to education administrators, school managers, teachers and other education stakeholders on students' performance in the subject.

This report highlights factors contributed to the performance of the students when attempting the questions. The factors include the failure to understand the demand of the questions, inadequate knowledge of the topics stipulated in the syllabus, inability to link theories and principles to perform questions involving computations and lack of drawing skills.

It is believed that the feedback provided in this report will enable education administrators, heads of schools, school managers, teachers and other stakeholders to identify and take proper measures to improve the teaching and learning of Engineering Science in Technical Secondary Schools. This will eventually improve students' performance in future assessments administered by the Council.

Finally, the Council would like to thank all those who participated in processing and analysing the data used in this report.

Dr. Charles E. Msonde
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report analyses students' responses to each question in the Form Two National Assessment (FTNA) of 2020 in the Engineering Science subject. The paper assessed the students' competences in various topics as stipulated in the Engineering Science Syllabus for Secondary School Education (Form One to Two):

The Engineering Science assessment paper had ten (10) questions divided in two sections A and B. Section A comprised 3 questions, each weighed 10 marks to make a total of 30 marks. Section B comprised 7 questions; each carried 10 marks to make a total of 70 marks. The students were instructed to answer all questions in both sections.

A total of 1692 students sat for 2020 Engineering Science paper whereby 808 (47.8%) students, passed while 885 (52.2%) failed. In 2019, the students who sat for the Engineering Science paper were 1705. Among them 998 (58.3%) students passed' while 707 (41.7%) failed. This indicates that the students' performance in this year has decreased by 10.8%. The comparison of students' performance in Engineering Science in 2019 and 2020 is presented in Figure 1.

The report analyses the students' responses to each question by giving an overview of what they were required to do, the general performance and the reasons for their performance. Samples of their good and poor responses are included in the analysis of each question.

In this report, the students' performance is categorised as 'weak', 'average', and 'good' if the percentage of their performance ranges from 0 to 29 (Red), 30 to 64 (yellow) and 65 to 100 (green), respectively. The red, yellow and green colours are used to represent weak, average and good performance respectively. A summary of the students' performance on each topic is shown in the Appendix.

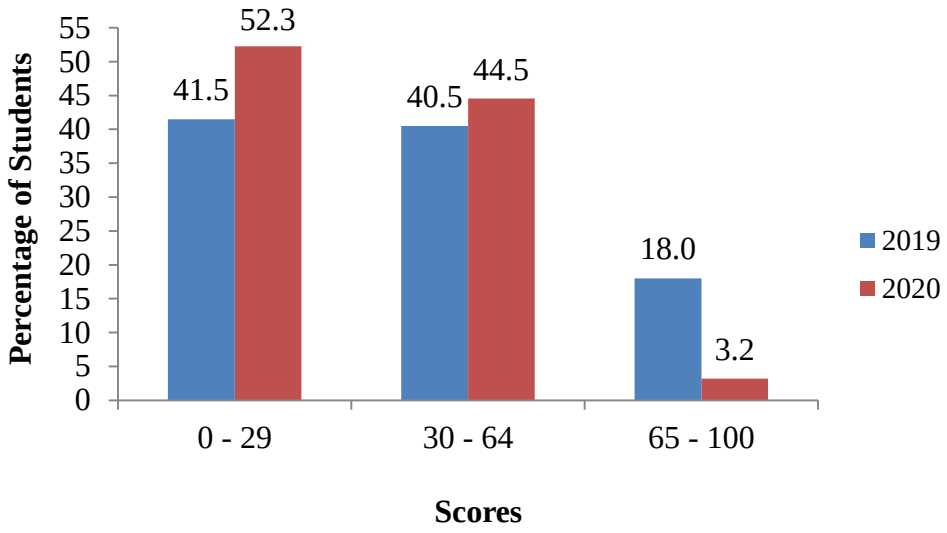


Figure 1: The comparison of students' performance in Engineering Science in 2019 and 2020

2.0 ANALYSIS OF STUDENTS' RESPONSES TO EACH QUESTION

2.1 SECTION A: Objective and Short Answer Questions

This section consisted of three questions, which were multiple choice items, True and False items and Filling in the blanks items. Each question consisted of 10 items, each carrying 01 mark, making a total of 30 marks for the whole section.

2.1.1 Question 1: Multiple Choice Items

The question consisted of ten (10) multiple choice items, each carrying 1 mark, making a total of 10 marks. The items were set from the topics of *Sound, Work, Energy and Power, Simple Machine, Heat, Light, Turning Force, Friction, Linear Motion* and *Force.* The question instructed the students to choose the correct answer from the given five alternatives and to write its letter beside the item number.

All 1693 (100%) students attempted this question, and their scores were as follows: 152 (9%) students scored from 0 to 2 marks; 878 (51.8%) students scored from 3 to 6 marks; and 663 (39.2%) students scored from 7 to 10 marks. The data analysis indicates that the general performance on this

question was good since 1541 (91%) students scored from average and above. The performance on this question is illustrated in Figure 2.

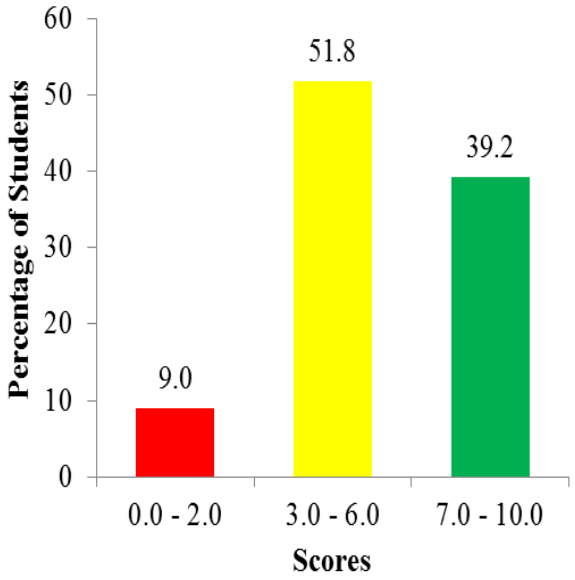


Figure 2: *The percentages of the students' performance on Question 1*

On the other hand the students scored good marks responded correctly to most of the items. This shows that they had good knowledge and skills in different concepts of Engineering Science tested. On the other hand, students who scored poorly had inadequate knowledge about some of the topics tested; they failed to choose the correct responses from the given alternatives. The majority of the students responded poorly to items (ii) and (viii).

The analysis of the students' responses indicates that, in item (ii), the students were required to identify the class of lever in which its effort is positioned between the fulcrum and the load. The correct answer was D, *third class.* Most of the students chose incorrect alternatives C; *Second Class*; 'A' *fifth class*; and 'B' *sixth class.* These students failed to use the knowledge about simple machine to identify the classes of levers. They failed to recognise that a lever is a simple machine consisting a beam or rigid rod pivoted at a fixed hinge or fulcrum. Furthermore, they failed to identify the class of the lever based on the location of the load, fulcrum and effort. This indicates that they lacked sketching skills which could help them to sketch the classes of levers with different positions of the fulcrum, load and effort and, therefore, to identify the class of lever easily.

The analysis indicates that, in item (viii), most of the students chose incorrect alternative 'B' *The voltage increases with the increase in resistance*. The correct alternative was 'A' *The current increases with the increase in potential difference.* The students who failed to choose the correct alternative lacked knowledge of electricity and magnetism, especially Ohm's law. They failed to understand that, Ohm's law is the relationship of the electric current, the potential difference across the conductor, and the resistance of the conductor. Others chose 'C' *The current increases with the decrease in potential difference* and 'D' *Both resistance and current increases with the increase in voltage.* The students lacked knowledge about the topic of electricity and magnetism.

In item (i), the question required the students to demonstrate how heat energy could reach a person who sits in front of an open coal fire. Most of the students selected the correct alternative 'D' *radiation*. Others selected distractors 'C' *convection,* 'A' *conduction* or 'B' *induction*. These students confused that heat energy reaches someone through air. They did not understand that convection is the transfer of heat through liquids and gases but heat transfer by radiation occurs when microwaves, infrared radiation, visible light, or another forms of electromagnetic radiation is emitted.

Item (iii) required them to identify an action pair of forces for a box on a bench. The students who selected the correct response 'A' *Force exerted by box on a bench: force exerted by bench on box* had adequate knowledge of Newton's third law of motion, whereby whenever two objects interact, they exert equal and opposite forces on each other. Those who chose 'B' *Force exerted by earth on a box: force exerted by bench on box*, were wrong because earth exerts force on a bench and not on a box, and the relationship here is between the bench and the box. Likewise, response 'C' "*Force exerted by box on a bench: force exerted by earth on box* was incorrect because the earth exerts force directly on the bench instead of the box. Furthermore, some students chose 'D' *Force exerted by earth on a box: force exerted by earth on bench*, which was wrong since the relationship of these pair of forces were on box and bench. The students confused the relationship between the earth and the bench whereby each produces an opposite force to sustain the state of equilibrium.

Item (iv) required the students to identify the physical quantity which is mostly closely related to inertia. The options were 'A' W*e*ight, 'B' *Force* 'C', *Mass* and 'D' *Acceleration*. The correct answer was option 'B' *Force*. Most of the students chose the required response. Some students selected the incorrect alternatives. For example, some students chose alternative 'C' *Mass*. These students lacked knowledge of the concept of the mass. They failed to understand that inertia is the resistance of any physical object to any change in its velocity. Accordingly inertia consists of both mass and velocity, which is most closely related to force consisting mass and velocity as well.

Item (v) required the students to choose the alternative which expresses the difference between a musical note and noise. The responses were 'A' *Noise is louder and of lower pitch*, 'B' *Noise is of lower frequency*, 'C' *Noise is formed by irregular vibrations* and, 'D' *Noise is formed by regular vibrations*. Alternative 'C' was the correct answer to this question. Most of the students chose the correct response. This indicates that they had knowledge of the characteristics of a musical note and noise. A few students who selected other incorrect options (A, B and D) lacked knowledge of the concept of musical note and noise.

In item (vi), the students were required to choose the statement which described translucent substances. The correct alternative was 'B' *allow parts of the light rays to pass through them*. The performance on this item was good as most of the students chose the correct answer. These student were knowledgeable about the topic of electricity and magnetism. A few students chose the incorrect answers 'A', *do not allow light rays to pass through then*, 'C' *allow light rays to pass through* then and 'D' *change the direction of all light rays that fall on them*. Those who chose alternative A did not know that translucent substances allow light to pass through them, but they diffuse the light which makes objects on the opposite side appear blurred. Those who selected alternative 'C' did not know that only transparent substances allow light to pass through them. Similarly, those who chose 'D' did not understand that examples of translucent substances are frosted glass, oil paper, some plastics, ice and tissue paper, which only diffuse light rays but do not change their direction.

Item (vii) required the students to choose the response which presents the name of a grooved wheel which is free to turn about a fixed axle. The correct alternative was 'C' *Pulley*. Other distractors included 'A' *Pivot*, 'B' *Gear* and 'D' *Screw*. The majority of students chose the correct alternative 'C' *Pulley* which indicates that they had adequate knowledge about the properties of Pulley. Some of the students who selected alternative 'B' *Gear* lacked knowledge about the concept of pulley, which is free to turn in a simple machine. They did not know that the gear is merely a toothed wheel that works with others to alter the relation between the speeds of a driving mechanism but the *Pulley* is a simple machine and comprises a wheel on a fixed axle, with a groove along the edges to guide the rope or cable. Pulleys are used to reduce the time and energy taken to lift heavy objects.

Item (ix) required the students to choose the alternative which represents the slope of the velocity against time in a graph. The options were 'A' *velocity*, 'B' *displacement*, 'C' *momentum* and 'D' *acceleration*. The correct answer was alternative 'D' *acceleration*. Most of the students chose the correct alternative 'D' *acceleration*. These students had enough knowledge that slope in a velocity-time graph indicates an object is accelerating. A few students chose incorrect alternative 'B' *displacement.* Their responses showed that they confused between the slope and area of the velocity-time graph. They did not understand that displacement is represented by the area on the velocity-time graph.

In item (x), the students were required to choose the alternative that is preferred in measuring mass. The correct alternative was 'C' *matter*. Most of students chose the correct answer. A few students chose incorrect responses 'A' *weight,* 'B' *Inertia* and 'D' *Gravity*. Those who chose alternative 'A' did not understand that weight is the force exerted on a body by gravity, and those selected alternative 'B' did not understand that inertia is a property of matter by which it continues in its existing state of rest or uniform motion in a straight line, unless that state is changed by an external force. Similarly, those who chose 'D' did not understand that Gravity is the force that attracts a body towards the centre of the earth, or towards any other physical body having mass.

2.1.2 Question 2: True or False

This question was set from different topics of Form One and Two. It consisted of ten (10) True and False statements. The question required the students to write TRUE if the statement was correct or FALSE if the statement was not correct.

All 1693 (100%) students attempted this question, and their scores were as follows: 469 (27.7%) students scored from 6.5 to 10 marks; 736 (70.1%) students scored from 3 to 6 marks, making a total of 97.8 percent of students who scored 3 marks or above. A few 38 (2.2%) students scored 2 or below. Therefore Question 2 was the most well performed question in this paper. Figure 3 shows the students' performance.

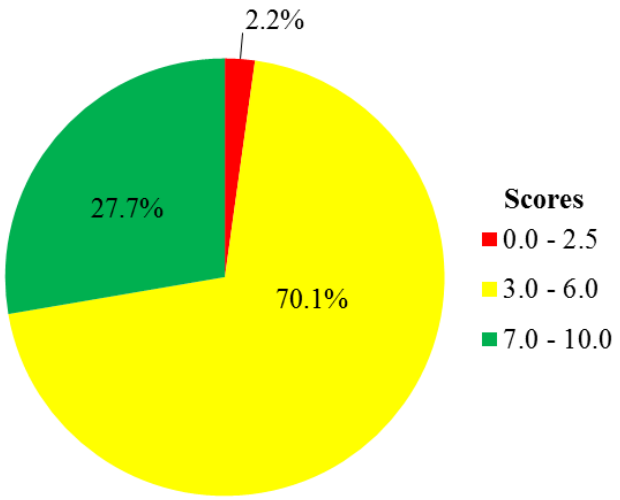


Figure 3: *Percentage of students' performance on Question 2*

The analysis indicates that most of the students scored high (7-10) marks in this question because they had enough knowledge about the topics tested. They correctly identified the statements. Extract 2.1 is a sample of good responses.

2. For each of the following statements, write **True** for the correct statement or **False** for incorre statement in the blank spaces provided.

(i) If the force and distance are perpendicular no work is done .....True.....

(ii) Weight is defined as a measure of the matter contained on an object. ....False.....

(iii) The length of oscillation depends on the length of the simple pendulum ....True.....

(iv) An inclined plane makes easy to move a load by increasing the distance....True.....

(v) Archimedes' principle is also known as the law of submergence.....False.....

(vi) When a person perspires on a hot day his body is insulated from the warm air...False

(vii) The lamp with the higher voltage has a filament of higher resistance.....False.....

(viii) Loud speakers are used to convert electrical energy to sound energy. .....True.....

(ix) Fluid resistance is the force exerted on an object moving through a fluid.....True.....

(x) Graphite is the among of the material used to reduce friction ....True.....

Extract 2.1: A sample of good response

Extract 2.1 shows a sample of good responses from one of the students who correctly answered all items of the question.

In item (i), the students were required to justify whether it is 'True' or 'False' that no work was done when the force and distance were perpendicular. Most of the students responded 'True' to this item. It showed that these students had knowledge about the concept of work done, and they understood that, the work done is the product of force and distance provided that the force is in the direction of the distance covered. In contrast, the students who responded 'False' did not understand that, when force is perpendicular to the direction of the distance covered, no work is carried out.

Item (ii) required them to recognize whether if is 'True' or 'False' that weight is defined as a measure of the matter contained in an object. Most of the students understood that the referent was mass. Therefore, they responded to this item as 'False'. There were few students whose responses were 'True'. These students did not recognize that the weight of an object is the force exerted on a body by gravity or it is the force acting on the object due to gravity. Besides, they did not understand that mass is the matter contained in an object.

Item (iii) required them to validate that "the length of oscillation depends on the length of the simple pendulum". Most of the students wrote 'True' while few of them wrote 'False'. Those whose response was 'False' did not understand that two pendulums with different lengths have different periods; the pendulum with the longer string have a longer period, while the one with the shorter string will have a shorter period. This showed that they lacked knowledge about the concept of time period of oscillation of a simple pendulum which depends on the length of the pendulum, the mass of the bob, and acceleration due to gravity.

Item (iv) required the students to write whether the statement "inclined plane makes easy to move a load by increasing the distance" is "True" or "False". Most of the students wrote 'True', while a few wrote 'False. Those who wrote 'False' failed to recognize that using an inclined plane makes it easier to move an object upward. Furthermore, they did not understand moving an object in an upward direction on an inclined plane takes less force than lifting the object straight up. Moving the object up on the inclined plane requires moving it at an increased distance. This revealed that these students lacked knowledge about the concept of inclined plane.

In item (v), the students were required to identify whether the Archimedes principle was also known as the law of submergence. Most of the students were confused by the word 'submergence'. Therefore, they wrote 'True'. They did not understand that the Archimedes principle is also known as the law of buoyancy. A few students managed to recognize that the Archimedes principle was not known as the law of submergence and responded 'False' to this item. They understood that it was the law of buoyancy and not submergence.

Item (vi) required the students to validate the statement that "when a person perspires on a hot day his body is insulated from warm air". The majority wrote 'False', but a few wrote 'True'. The correct response was 'False'. Those whose response was 'True' were not aware that perspiration or sweating is the release of a salt-based fluid from the sweat glands, and this process has nothing to do with insulating the body from warm air. Others in this group did not understand the question and decided to write 'True'.

Item (vii) required the students to respond to whether the statement "the lamp with the higher voltage has a filament of higher resistance" is 'True' or 'False'. The majority wrote False while a few of them wrote 'True'. The correct response was 'False'. The students whose response was 'True' lacked knowledge about the concept that the voltage supplied to a filament remains relatively constant, and it is regulated by the electric company

when plugged into the wall or the grid. The current is inversely proportional to resistance as per Ohms law. Therefore as the resistance goes down, the current goes up. Thus it is not true that the lamp with a higher voltage has a filament of higher resistance.

Item (viii) stated "loud speakers are used to convert electrical energy to sound energy". The majority wrote "True" whereas a few students wrote 'False'. The correct response was 'True'. The analysis showed that most of the students had knowledge about the topic of sound, especially speakers. They understood that the loudspeaker is a sound reproduction device for converting electrical energy into acoustical signal energy. The students were knowledgeable of the energy transformation. They knew that electrical energy can be transformed to sound energy.

Item (ix) required the students to respond to whether the statement. "Fluid resistance is the force exerted on an object moving through a fluid" is 'True' or 'False'. The response by the majority was 'True'. The correct response was 'True'. A few students wrote 'False' and this showed that they lacked knowledge about 'fluid drag' or 'fluid resistance'. Furthermore, they did not understand that fluid resistance is the force acting opposite to the relative motion of any object moving with respect to the surrounding fluid.

Item (x) required the students to say whether the statement "graphite is the among the materials used to reduce friction" is "True" or "False". The majority of the students wrote 'True', while a few wrote 'False'. The students whose response was 'False' lacked knowledge of the topic of friction, especially the materials used to reduce friction. They did not understand that graphite is a natural form of crystalline carbon. Furthermore, they did not understand that graphite has lower shearing strength under friction force. Therefore, it is considered as a solid lubricant and one of the traditional and primary solid lubrication materials.

On the other hand, few 28 (2.2%) students scored from 0 to 2 marks. Most of them lacked the knowledge about the topics tested. They failed to understand whether the statement were 'true' or 'false' Thus, they resorted to guessing by writing incorrectly either True or 'False'. Consequently they scored either 0, 1 or 2 marks. Extract 2.2 is a sample of the poor responses.

2. For each of the following statements, write **True** for the correct statement or **False** for incorrect statement in the blank spaces provided.

(i) If the force and distance are perpendicular no work is done ..... False .....

(ii) Weight is defined as a measure of the matter contained on an object. ..... True .....

(iii) The length of oscillation depends on the length of the simple pendulum ..... False .....

(iv) An inclined plane makes easy to move a load by increasing the distance..... False .....

(v) Archimedes' principle is also known as the law of submergence..... True .....

(vi) When a person perspires on a hot day his body is insulated from the warm air..... ~~False~~ True

(vii) The lamp with the higher voltage has a filament of higher resistance..... True .....

(viii) Loud speakers are used to convert electrical energy to sound energy. ..... False .....

(ix) Fluid resistance is the force exerted on an object moving through a fluid..... False .....

(x) Graphite is the among of the material used to reduce friction ..... False .....

Extract 2.2: A sample of poor responses to the question

Extract 2.2 is a sample of incorrect responses to this question. The student had insufficient knowledge of the given statements. As a result he/she failed to comprehend them and decide whether were true or false.

2.1.3 Question 3: Filling in the Blanks

This question had ten (10) items with incomplete statements. The students were required to complete the statements by writing correct answers in the spaces provided. The items were constructed from the topics of *Sound, Work, Energy and Power*, *Simple Machine, Heat, Light, Turning Force, Friction, Linear Motion* and *Force*. The question carried a total of ten (10) marks, each item carrying one (01) mark.

The question was attempted by 1690 (99.8%) students. Among them 418 (24.7 %) students scored from 0 to 2 marks; 825 (48.9%) students scored from 3 to 6 marks and 447 (26.4%) students scored marks from 7 to 10 marks. The student demonstrated good performance on this question as 1272 (75.3%) students scored 3 marks and above. Figure 4 shows the students' performance on this question.

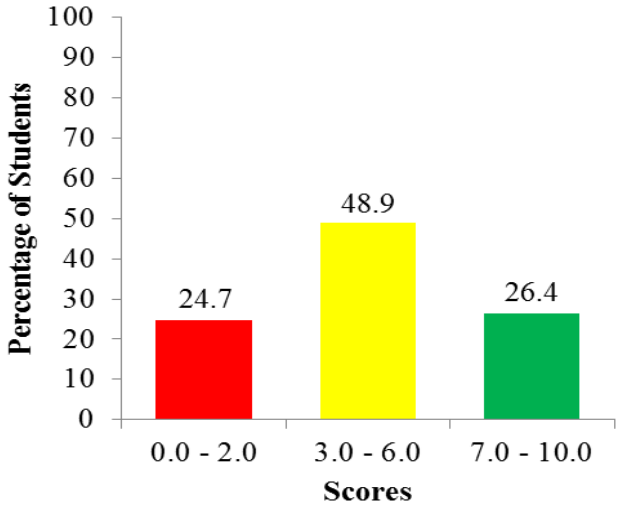


Figure 4: *Students' Performance on Question 3*

Item (i) required the students to state the medium through which sound waves cannot travel in contrary to light wave which does. The correct answer was *Vacuum.* The majority of the students wrote the correct response in this item, while a few provided either incorrect answers or failed to write anything. It was noted that those who wrongly wrote *air* did not know that sound waves travel only on a medium while light travels even in vacuum.

In item (ii), the students were required to answer what an object with the capacity for doing work possesses. The correct response was *Energy*. Most of the students wrote the correct answer to this item, except for a few students who lacked knowledge of the tested concept. Hence, they did not write anything or completed the statement by writing irrelevant engineering science terminologies such as *power* and *force*. The students were supposed to understand that Energy is the ability of doing work.

Item (iii) required the students to complete the statement by writing the term which could represent the formula for the calculations of the force ratio of a certain machine. The correct answer was *effort.* Most of the students failed to fill in the correct answer, implying that they did not understand the formula of the force ratio with relation to load and effort. They did not recognize that the force ratio, which is also known as Mechanical advantage, is the ratio between the forces applied to the load. They were further supposed to understand that this ratio is also elaborated as the ratio of the output force (load) of a machine to the input force (effort).

Item (iv) required the students to write the name given to an instrument used to measure temperature. The correct answer was *Thermometer*. The performance of the students on this item was good as most of them wrote the correct answer. They had adequate knowledge of unit and measurement, with respect to the engineering science subject.

In item (v), the students were required to complete the statement by writing the name of the substance that does not allow light to pass through it. The correct answer was *opaque*; The performance on this item was poor as the majority of students wrote incorrect answers. They wrote *translucent* as a substance which does not allow light to pass through. These students lacked knowledge about the concept that translucent substances causes objects on the opposite side to appear unclear but allow light to pass through.

Item (vi) required the students to write the name given to the distance between two successive threads in a screw jack. The correct answer was *Pitch.* The performance of the students on this item was good as most of them wrote the correct answer. The majority of the students had the adequate knowledge of the concept of pitch in relation to threads. A few students failed to recall the correct answer. Therefore, they could not fill in the correct response. These students filled in the wrong answer *trough* instead of *pitch*. They seemed to confuse the terms applied to waves such as 'wavelength', 'trough', 'pitch' of the wave for those used in thread nomenclature.

In items (vii), the students were required to identify the factor on which the magnitude of the turning moment depends. The correct answer was *Perpendicular distance of a force*. The majority of students wrote the correct response in this item. A few students either wrote incorrect answers or failed to write anything. It was noticed that those who wrote wrong answers such as *moment*, lacked knowledge the turning effect of a force. Furthermore, they did not understand that the moment of a force depends on the magnitude of the force and the perpendicular distance from the axis of rotation.

Item (viii) required the students to identify one of the two types of friction. They were provided with one type, which was Kinetic friction. The correct answer was *Static friction.* The performance of the students on this item was good as most of them wrote the correct answer. Only few students wrote incorrect responses. Some of them wrote *motion friction* while others

left the space blank. The analysis conducted showed that, the students did not understand the types of friction, namely Kinetic friction and Static friction. They further did not understand that Kinetic energy is a force that acts between moving surfaces and while Static friction is a force that keeps an object at rest or a force experienced when individuals attempt to move a stationary object on the surface without actually causing any relative motion between the body and the surface.

In item (ix), the students were required to write the name given to the area represented under the velocity-time graph. The correct answer was *distance* or *displacement*. The performance of the students on this item was good. Most of them wrote the correct answer as *distance* or *displacement*. Only few of them wrote incorrect responses. These students lacked knowledge about the concept of velocity, time and distance or displacement. Therefore, they failed to fill in the correct response. Some of them wrote wrong answers such as *acceleration*, *velocitytime* and *time*. They did not understand that the area under the velocity-time graph represents the distance travelled.

In items (x), the students were required to name the force which is numerically equal to the resultant of the system of forces and acts in the opposite direction along the same line of action. The correct answer was equilibrant. Only few students failed to write the correct response, indicating that they lacked knowledge about the concept of an equilibrant. These students did not understand that equilibrant is the force which brings an object into mechanical equilibrium as the equilibrium exists when the net force on the object is zero. They further lacked an understanding that the equilibrant force is equal in magnitude and opposite in direction to the resultant force. Extracts 3.1 is a sample of the good responses to the question.

3. Fill in the blank spaces by writing the correct answer:

(i) Unlike light waves, sound waves cannot travel through ...vacuum.....

(ii) Object that has the capacity for doing work is said to possess.....energy.....

(iii) The force ratio of a certain mashine is said to be a ratio of load over ...effort.....

(iv) The instrument used to measure temperature is known as ...thermometer.....

(v) The substance that does not allow light to pass through is called ....opaque.....

(vi) The distance between two successive threads in a screw jack is called ....pitch.....

(vii) The magnitude of the turning moment depends on .distance...from...the...pivot.....

(viii) The two types of friction are recognised as Kinetic friction and .....static...friction.....

(ix) The area represented under velocity – time graph is called ..distance...covered.....

(x) The force which is numerically equal to the resulatant of the system of forces and acts in the opposite direction along the same line of action is known as Equilibrant...force...

Extract 3.1: *A sample of the student's good responses to Question 3*

Extract 3.1 is a sample of the response provided by a student who was able to remember the concept and filled them in correctly in those statements. Thus, he/she scored 10 marks.

3. Fill in the blank spaces by writing the correct answer:

(i) Unlike light waves, sound waves cannot travel through ...Friction.....

(ii) Object that has the capacity for doing work is said to possess.....Force.....

(iii) The force ratio of a certain mashine is said to be a ratio of load over ....Acceleration

(iv) The instrument used to measure temperature is known as ...volume.....

(v) The substance that does not allow light to pass through is called ....low voltage

(vi) The distance between two successive threads in a screw jack is called ...Pulley.....

(vii) The magnitude of the turning moment depends on ...load.....

(viii) The two types of friction are recognised as Kinetic friction and ...Kinetic...Energy

Extract 3.2: *A sample of students' poor responses to Question 3*

Extract 3.2 is a sample of part of the responses of a student who failed to answer correctly the statements and scored only one mark on (ix) item via the correct answer *displacement*. This indicates that some students had inadequate knowledge about different topics.

2.2 SECTION B: Structured Questions

2.2.1 Question 4: Fluid Mechanics

This question was set from the topic of Fluid Mechanics. The tudents were required to calculate the volume of the liquid displaced by a floating object when an object of volume $0.5m^3$ and density $1500kg/m^3$ floats in a liquid of density $1000kg/m^3$.

The question was attempted by 1590 (93.9%) students. Among them, 1018 (64%) scored 0 to 2.5 marks; 372 (23.4%) students scored from 3 to 6 marks; and 200 (12.6%) students scored from 6.5 to 10 marks. Data analysis reveals that the performance was poor as 64 percent of the students scored low (0 to 2.5) marks. The performance on this question is shown in Figure 5.

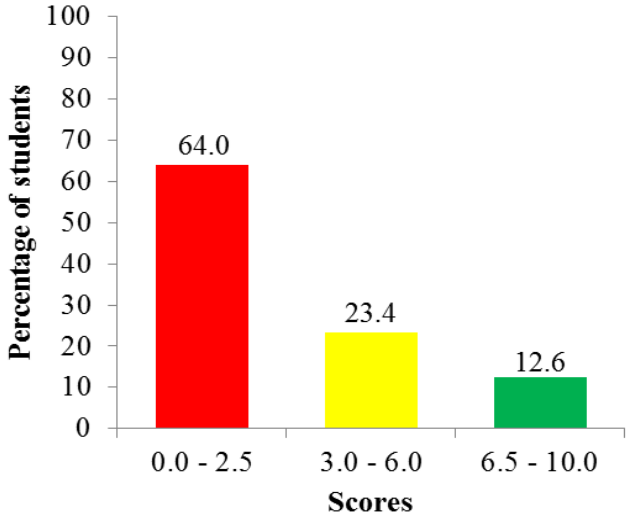
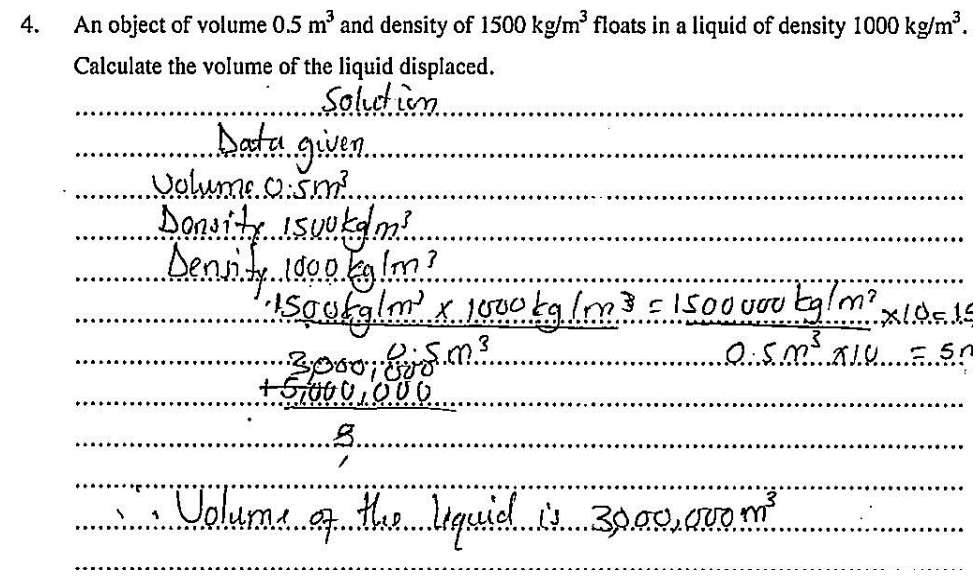


Figure 5: *Student's performance on Question 4*

With regard to the data analysis made on the performance of the students it was observed that most of the students failed to calculate the volume of the liquid displaced from a floating object because they could not recall the floatation law, which could lead them to write the equation. According to

the law of floatation, *the mass of a floating object which is equal to the mass of liquid displaced*. Some of them wrongly equated that the volume of object floating on liquid is equal to the volume of liquid displaced by an object. Others wrote the correct formula, but they did not follow the right steps to calculate the volume of the liquid displaced. Hence, they derived the wrong answer. As a result these 64.0% students student scored from 0 to 2.5 marks. Extract 4.1 shows a sample of poor responses by a student who failed to attempt Question 4.


4. An object of volume 0.5 m^3 and density of 1500 kg/m^3 floats in a liquid of density 1000 kg/m^3. Calculate the volume of the liquid displaced.

Solution

Data given

Volume 0.5m^3

Density 1500kg/m^3

Density 1000kg/m^3

1500kg/m^3 x 1000kg/m^3 = 1500000kg/m^3 x10=15

3000,0.5m^3 0.5m^3 x10 = 5

+5000,000

8

∴ Volume of the liquid is 30,000,000m^3

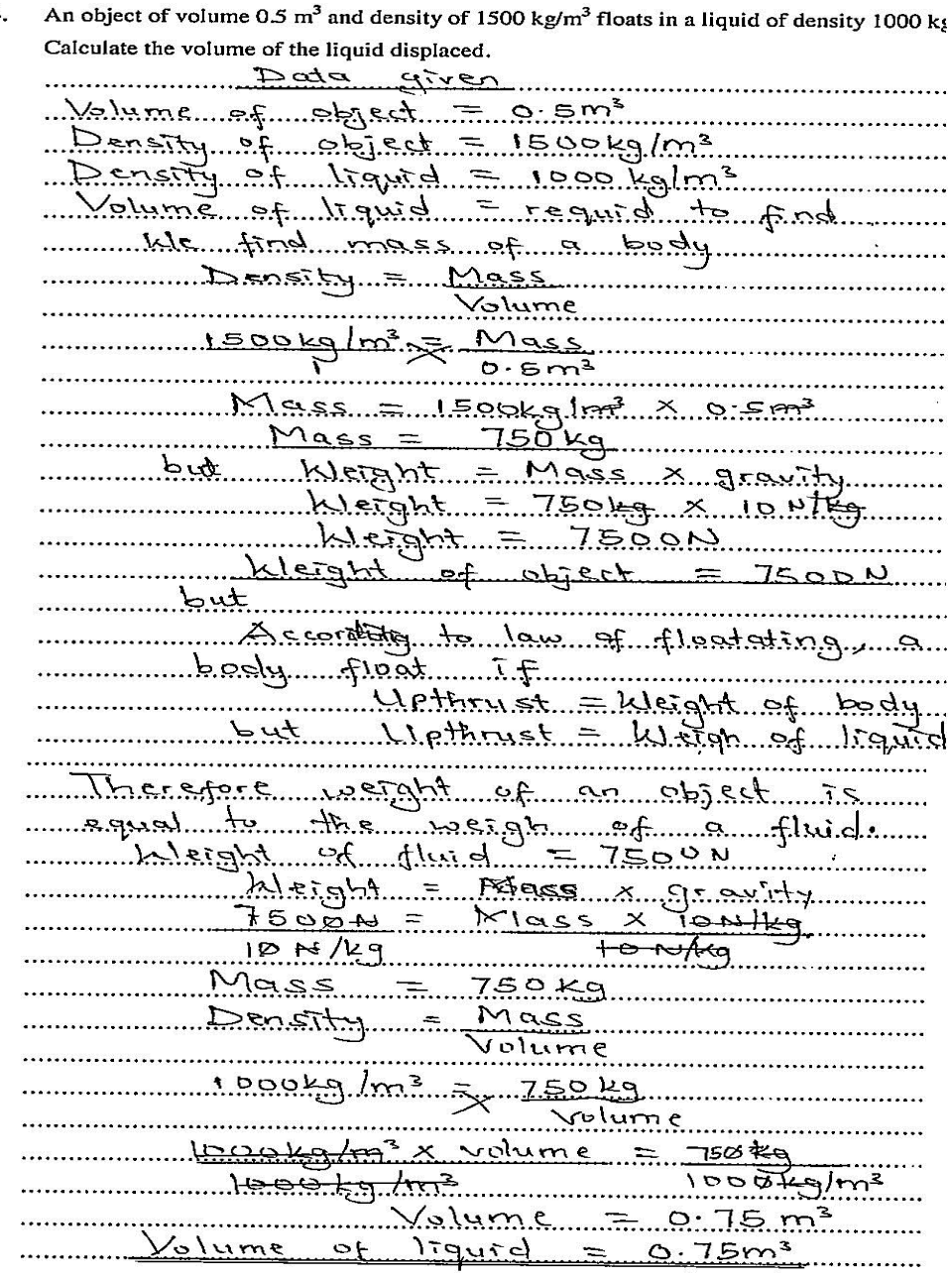
Extract 4.1: *A sample of students' poor responses to Question 4*

Extract 4.1 shows a poor response from the script of one student who failed to know that the mass of the object floating is equal to the liquid displaced by the object. He/she failed to write the correct formula for density to calculate the mass of an object and volume of the liquid displaced. As a result, he/she provided the incorrect responses.

However, other students wrote the correct formula for density and found the mass of the object but failed to justify that mass of the liquid with that of the liquid displaced by the object. Therefore, this category of students performed averagely by scoring from 3 to 6 marks.

Some of the students applied the correct formula for density and made the correct substitution of data to calculate the mass of the object. They also

correctly used the floatation law to find the mass of the liquid displaced. They recognized that the mass of object is equal to the mass of liquid displaced. They knew that a floating object displaces its own mass of the fluid on which it floats. As a result, they scored high (6.5 to 10) marks on this question. Extract 4.2 provides a sample of good responses.


4. An object of volume 0.5 m^3 and density of 1500 kg/m^3 floats in a liquid of density 1000 kg
Calculate the volume of the liquid displaced.

Data given
Volume of object = $0.5m^3$
Density of object = $1500kg/m^3$
Density of liquid = $1000kg/m^3$
Volume of liquid = required to find
We find mass of a body
Density = Mass / Volume
$1500kg/m^3$ = Mass / $0.5m^3$
Mass = $1500kg/m^3 \times 0.5m^3$
Mass = 750kg
but Weight = Mass x gravity
Weight = 750kg x 10N/kg
Weight = 7500N
Weight of object = 7500N
but
According to law of floatating, a body float if
Upthrust = Weight of body
but Upthrust = Weigh of liquid
Therefore weight of an object is equal to the weigh of a fluid.
Weight of fluid = 7500N
Weight = Mass x gravity
7500N / 10N/kg = Mass x 10N/kg / 10N/kg
Mass = 750kg
Density = Mass / Volume
$1000kg/m^3$ = 750kg / Volume
$1000kg/m^3 \times$ volume = $750kg / 1000kg/m^3$
Volume = $0.75 m^3$
Volume of liquid = $0.75m^3$

Extract 4.2: *A sample of the student's good responses to Question 4.*

Extract 4.2 is a sample of a good response given by the student who followed all the procedures and calculated correctly the volume of liquid displaced.

2.2.2 Question 5: Work, Energy and Power

This question stated that a load is hauled along a track with a tractive effort 'F' which varies with the displacement in the direction of the force in the following manner:

F in kN	1.6	1.4	1.2	1.0	0.8	0.6
S in meters	0	10	20	30	40	50

The students were required to:

(i) Draw the force – displacement graph

(ii) Determine the work done in moving the load from displacement 0 to 50 m.

The question was attempted by 1433 (84.6%) students. Among them, 1232 (86%) scored from 0 to 2.5 marks; 181 (12.6%) scored from 3 to 6 marks; and 20 (1.4%) scored from 6.5 to 10 marks. The analysis shows that the general performance on this question was weak since only 14 percent of the students scored from average and above. Figure 6 shows the performance of the students on this question.

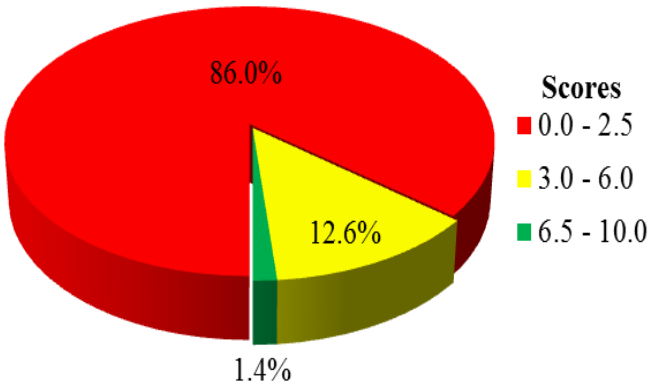
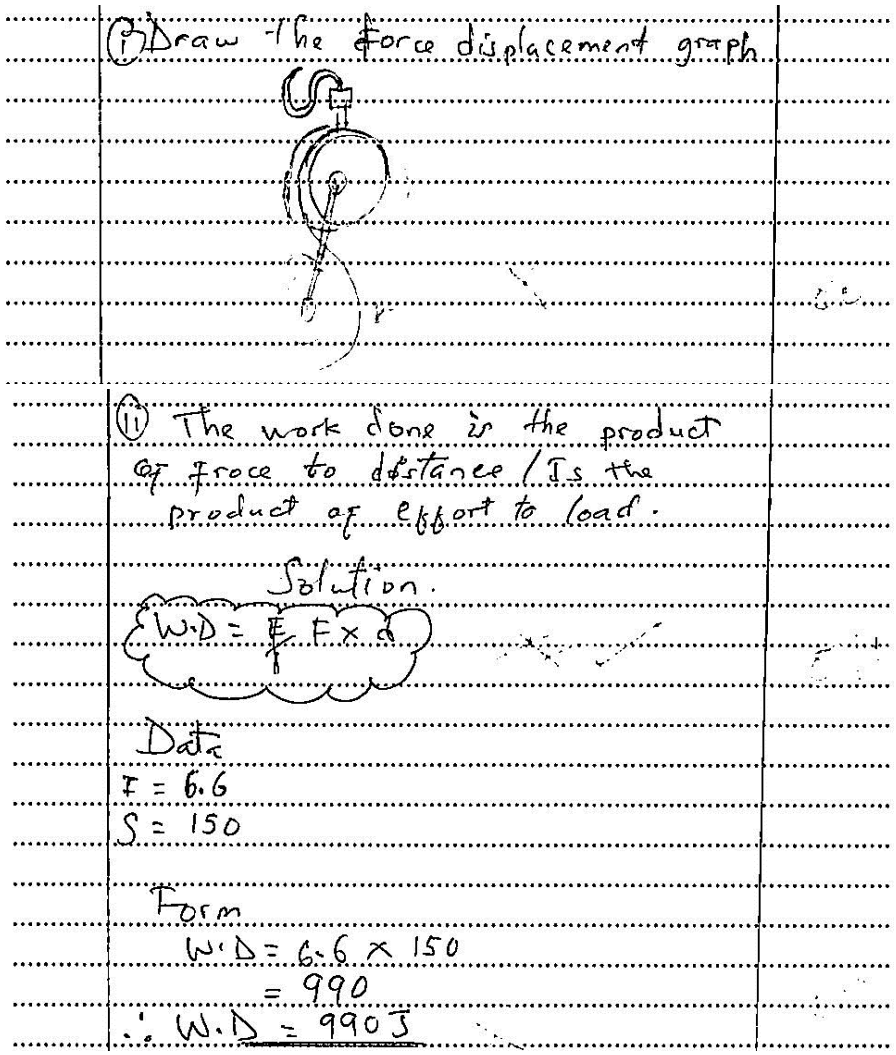


Figure 6: *Students' Performance on Question 5*

The data analysis shows that 86 percent of the students scored low marks, from 0 to 2.5 . The students with poor performance failed to draw force-displacement graphs. They just wrote the formula for work done correctly, but they substituted the data without calculating the value of the work done. Others failed to apply the concept of work done using forces as they were given in the table. Furthermore, they failed to use graphs to determine the work done in moving the load from displacement 0 to 50 m. Hence, most of them scored zero in part (ii) which depended on the correct solution of part (i) in the question. Extract 5.1 presents a sample of poor responses to this question.

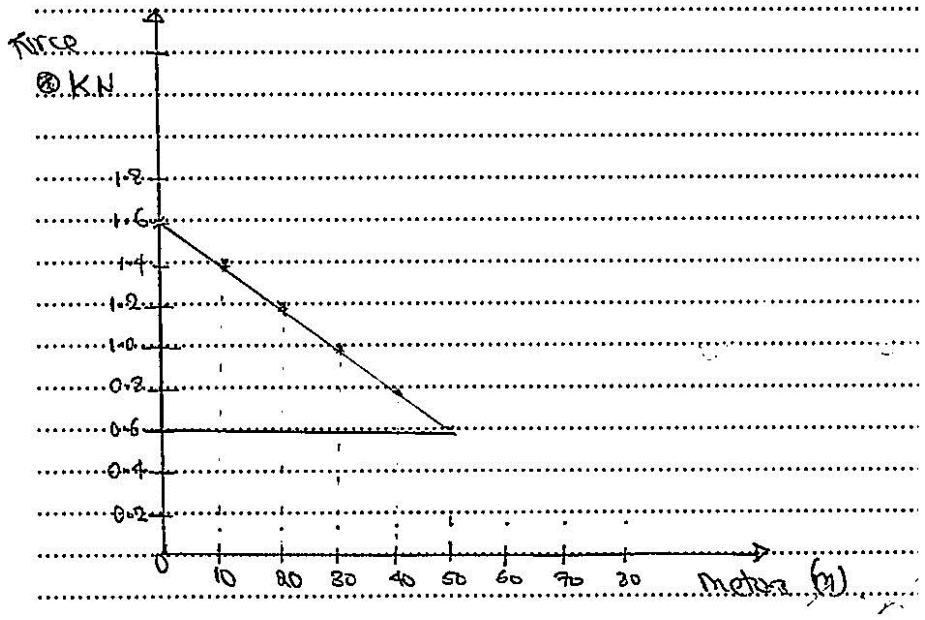


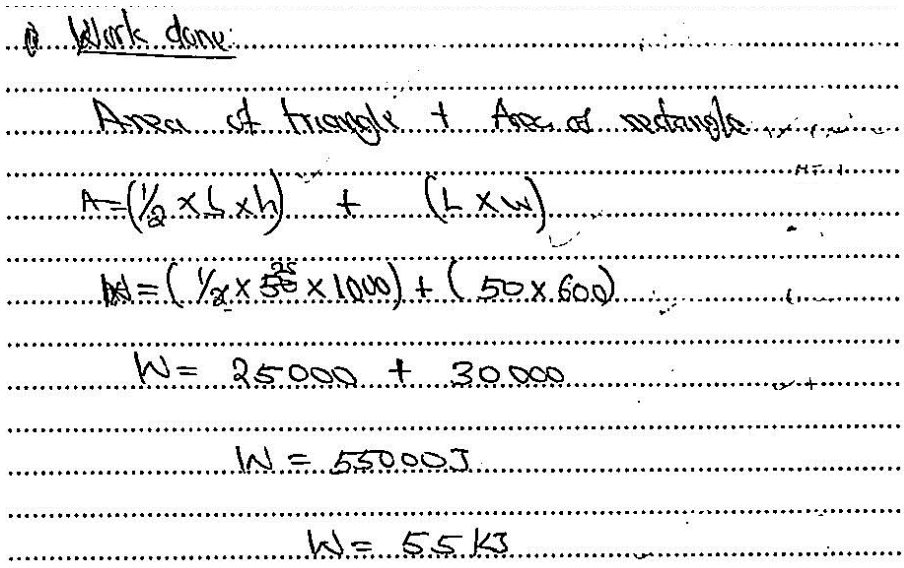
Extract 5.1: *A sample of students' weak responses in question 5*

Extract 5.1 is a sample of the responses from the student who wrote incorrect answers.

Some of the students drew force–displacement graphs and wrote the formula for work done in part (i) correctly but they failed to insert the correct data or to understand how to correlate the area under the graph with the given data. Thus they scored average (3 to 6) marks.

Few (0.8%) students scored high (6.5 to 9.5) marks, indicating that they managed to draw the force-displacement graph and used it to calculate the work done. Some of them used the formula for trapezium while others used the triangle formula to correctly calculate the work done. These students also determined the work done in moving the load from displacement 0 to 50 m. They had knowledge about sketching the force–displacement graph and used the formula correctly to calculate the work done. Extract 5.2 is a sample of good responses.





Extract 5.2: *A sample of the students' good responses to Question 5*

Extract 5.2 is a sample of good responses from the student who managed to determine the work done in moving the load from displacement 0 to 50 m. He/she divided the area under graph into two, as a triangle and rectangle, to calculate the area, which is the work done.

2.2.3 Question 6: Light (Optics)

This question was set from the topic of light. It comprised three parts (a), (b) and (c). In part (a), the students were required to distinguish between the eclipse of the moon and the eclipse of the sun. Part (b) required them to identify three properties of an image formed by a pin-hole camera and part (c) required the students to find the height of the image produced from an object 1 cm high placed 10 cm in front of the pin-hole.

The question was attempted by 1629 (96.2%) students. Among them 619 (38 %) scored from 0 to 2.5 marks; 578 (35.5%) scored from 3 to 6 marks; and 432 (26.5%) students scored from 6.5 to 10 marks. The general performance on this question was average asince 62 percent of the students scored 3 and above. Figure 7 shows the performance of the students on this question.

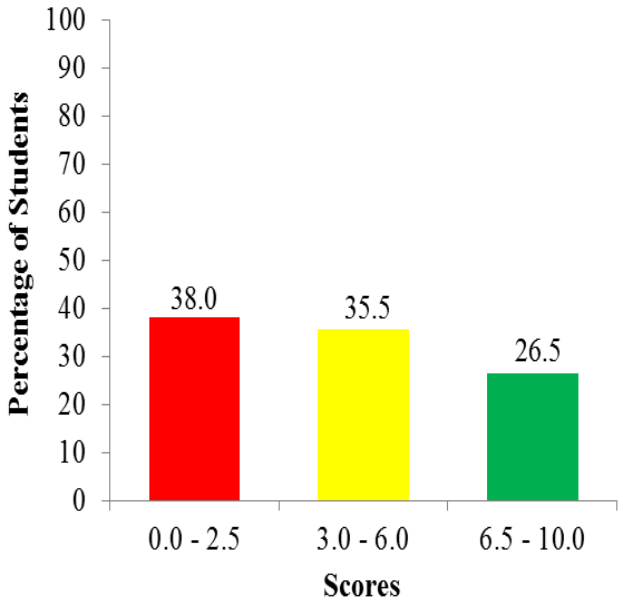


Figure 7: *Students' Performance on Question 6*

The average performance of students on this question was due to failure to distinguish between the eclipse of the moon and of the sun. They also identified correctly the three properties of image formed by a pin-hole camera. Furthermore in part (c) they calculated the height of the image formed using the correct formula ($\frac{h_i}{h_o} = \frac{v}{u}$) and correctly substituted the given data. These students had adequate knowledge of the pin-hole camera. Their responses revealed that they had knowledge and skills in testing various materials with a beam of light and in demonstrating shadows and eclipses. Extract 6.1 illustrates a sample of such good responses.

6. (a) Distinguish between the eclipse of the moon and the eclipse of the sun.

→ Moon eclipse - Refer to the eclipse that occurs when the earth is between the sun and the moon.

WHILE

- Sun eclipse this occurs when the moon becomes between the earth and the sun.

(b) Identify three properties of an image formed by a pin-hole camera.

(i) It real

(ii) It inverted

(iii) Is smaller than object.

(c) The distance between the hole and screen of a pin-hole camera is 30cm. An object 1cm high is placed 10 cm in front of the pin-hole. Find the height of the image produced.

Data:

Image distance = 30 cm.

height of Object = 1 cm.

Object distance = 10 cm.

height of the Image = ?

Go from.

the formula

$\frac{di}{do} = \frac{hi}{ho}$

$\frac{30\text{ cm}}{10\text{cm}} = \frac{hi}{1\text{ cm}}$.

$\frac{30}{10} = \frac{hi}{1}$.

Cross Multiplication.

$30 = 10 \times hi$

$30 = 10hi$

$\frac{10hi}{10} = \frac{30}{10}$

$hi = 3$ cm.

∴ Image height is 3cm.

Extract 6.1: *A sample of the student's good responses to Question 6*

Extract 6.1 shows a sample of good responses from the student who had adequate knowledge about the correct concepts of eclipses and provided the correct answers in parts (a) and (b). He/she correctly listed the three properties of an image formed by a pin-hole camera and wrote the correctly formula for calculating the distance between the hole and a screen of the pin- hole-camera, as the question asked.

Besides they correctly distinguished between eclipses of the moon and that of the sun. A further analysis revealed that some of the students correctly attempted part (a) and (b) but skipped part (c). Therefore, they obtained average scores (3.0 to 6.0 marks).

A further analysis shows that some students had poor performance on this question (0 to 2.5 marks). These students wrote only one correct property of image formed by a pin-hole camera out of the three properties. Others managed to write the formula in part (c) but failed to manipulate correctly the given data. These students had inadequate knowledge of the pin-hole camera and skills in testing various materials with a beam of light and in demonstrating shadows and eclipses. Extract 6.2 illustrates a sample of the poor responses.

6. (a) Distinguish between the eclipse of the moon and the eclipse of the sun.

Eclipse of the moon is that the moon is between the sun and earth.

WHILE

Eclipse of the sun is that the sun is between the moon and earth.

(b) Identify three properties of an image formed by a pin-hole camera.

(i) Clear pictures

(ii) To control the pin-hole from the picture.

(iii) To show the lightness.

(c) The distance between the hole and screen of a pin-hole camera is 30cm. An object 1cm high is placed 10 cm in front of the pin-hole. Find the height of the image produced.

Sln.

Data given

Pin-hole camera = 30cm

An object = 1cm

High is placed = 10 cm in front of the pin hole.

From:

The pin hole camera = 30cm

An object = 1cm

High is placed = 10cm

Height of the Image produced = x

So that

30cm × 1cm

= 30cm²

30cm² × 10cm = 300cm³

The heigh of the image produced is 300cm³

Extract 6.2: *A sample of students' poor responses to Question 6*

Extract 6.2 is a sample of the poor responses from one of the students who had wrong concept of eclipses in part (a). In part (b), the student listed the wrong properties of an image formed by the pin-hole camera and provided the wrong formula for calculating the distance between the pin-hole and the screen of the pin-hole camera.

2.2.4 Question 7: Simple Machine

This question had two parts (a) and (b) which stated,

(a) Figure 1 shows the compound gear train, gear wheel B and C are rigidly attached to an idler shaft. Wheels A, B and C have 60, 20 and 50 teeth respectively and the speed of A is 200 rev/min. calculate the number of teeth on wheel D so that its speed will be 1000 rev/min.

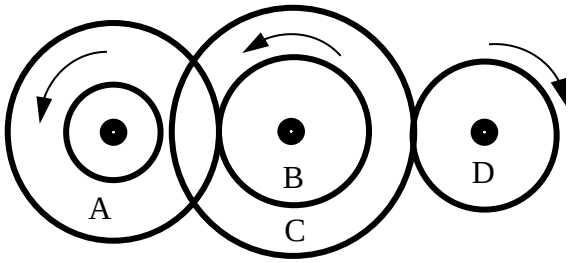


Figure 1

(b) Figure 2 shows a certain first class lever of length 2.5 m. The lever has a velocity ratio of 12 and an efficiency of 85%. Study the diagram carefully and then answer the questions that follow.

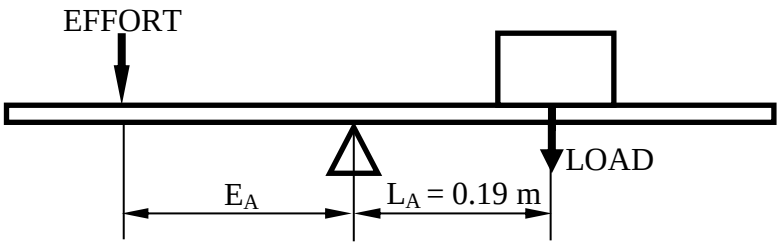


Figure 2

Where: E_A = Effort arm

L_A = Load arm = 0.19 m

(i) How far from the fulcrum must the force be applied?

(ii) What effort is required to lift a load of 75N?

The question was attempted by 1547(91.4%) students. Among them, 1000 (64.6%) students scored from 0 to 2.5 marks; 512 (33.1%) students scored from 3 to 6 marks; and 35 (2.3%) students scored from 6.5 to 10 marks. The general performance on this question was average as 35.4% percent of the students scored from 3 to 10 marks. Figure 8 shows the performance of students on this question.

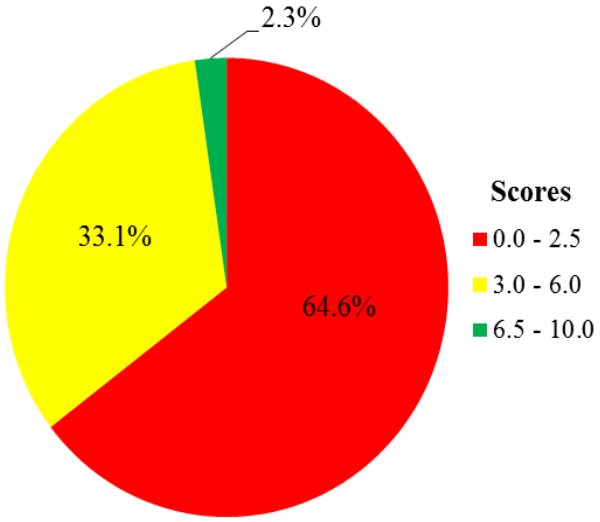


Figure 8: *Students Performance on Question 7*

The analysis shows that the majority of the students (64.6%) scored low marks (0 to 2.5) out of the 10 marks allotted to this question. These students failed to write the correct formula in part (a) as well as to calculate the number of teeth on wheel D. This is indicates that the students did not understand that one of the basic relationships for a gear is the number of teeth, the diameter, and the rotary velocity of gears. They were supposed to notice that the larger gear makes only a half-turn while the smaller one makes a complete turn. That is, the ratio of speeds (velocity ratio) of the large to the smaller is 1 to 2. Gears B and C rotate at the same speed because they are fixed to the same shaft. Part (b) of the question was done poorly because most of students lacked knowledge of the concept of moment, and they could not apply the formula "Velocity Ratio of a lever = $\frac{\text{Effort arm}}{\text{Load arm}}$ to calculate the distance from the fulcrum on which the force must be applied. They also failed to calculate the value of the effort required to lift a load of 75N. These students lacked knowledge of how a lever works. They did not understand that the side of the lever, where the input force applied, is called the input arm and the output arm. Moreover, they did not realise that, in levers, the fulcrum can be arranged so that the input and output arms achieve any mechanical advantage required. Extract 7.1 presents a sample of students' poor responses.

(b) Figure 2 shows a certain first class lever of length 2.5 m. The lever has a velocity ratio of 12 and an efficiency of 85%. Study the diagram carefully and then answer the questions that follow.

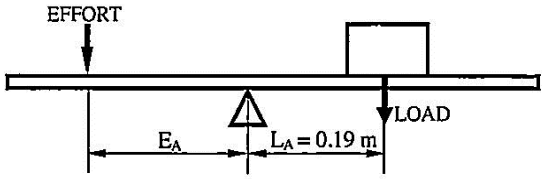


Figure 2

Where: E_A = Effort arm
L_A = Load arm = 0.19 m

(i) How far from the fulcrum must the force be applied?
(ii) What effort is required to lift a load of 75N ?

EFFORT ← ⋇ → LOAD
EA = LA = 0.19 m
Figure
Where EA = Effort arm
LA = Load arm = 0.19 m

Extract 7.1: *A sample of students' poor responses to Question 7*

Extract 7.1 illustrates a sample of poor responses from the student who wrote an incorrect answer.

A further analysis on this question shows that 33.1 percent of the students scored average (3 to 6) marks on this question because they only wrote the formula for velocity ratio in part (b) and some calculations, which lead them to score average marks. Others managed to write the formula in both parts (a) and (b) but failed to manipulate the given data using the formula. Thus, they scored average marks.

Nevertheless, few students (2.3%) scored high marks (6.5 to 10) on this question. These managed to answer all parts of the question correctly, leading them to score 10 marks. This indicates that they had a good understanding of the basic relationships for a gear, namely the number of teeth, the diameter, and the rotary velocity of gears in part (a). They wrote

the correct formula and used it to calculate the number of teeth on wheel D. They also managed to apply velocity ratio and the Load arm to calculate the Effort arm in part (b) (i). Consequently, they calculated correctly the effort required to lift the load of 75N in part (b)(ii). Extract 7.2 illustrate a good response from one of the students.

7. (a) Figure 1 shows the compound gear train, gear wheels B and C are rigidly attached to an idler shaft. Wheels A, B and C have 60, 20 and 50 teeth respectively and the speed of A is 200 rev/min. Calculate the number of teeth on wheel D so that its speed will be 1000 rev/min.

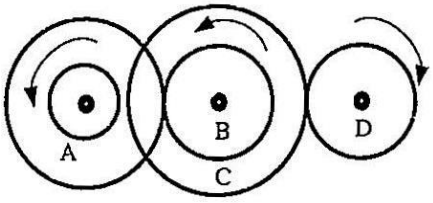


Figure 1

Data

Number of teeth on wheel A = 60
Number of teeth on wheel B = 20
Number of teeth on wheel C = 50
Speed of A = 200rev/min
Speed of D = 1000rev/min
Required is the number of teeth on wheel D.

From

$\frac{\text{Speed of A}}{\text{Speed of B}} = \frac{\text{Number of teeth B}}{\text{Number of teeth A}}$

$\frac{200\text{rev/min}}{B} = \frac{20}{60}$

$\frac{20 \times \text{Speed of B}}{20} = \frac{60 \times 200\text{rev/min}}{20}$

Speed of B = 600rev/min

But; Wheel B and C are rigidly attached to an idler shaft. So;

the Speed of B will be the Speed of C.

$\frac{\text{Speed of B}}{\text{Speed of D}} = \frac{\text{Number of teeth D}}{\text{Number of teeth C}}$

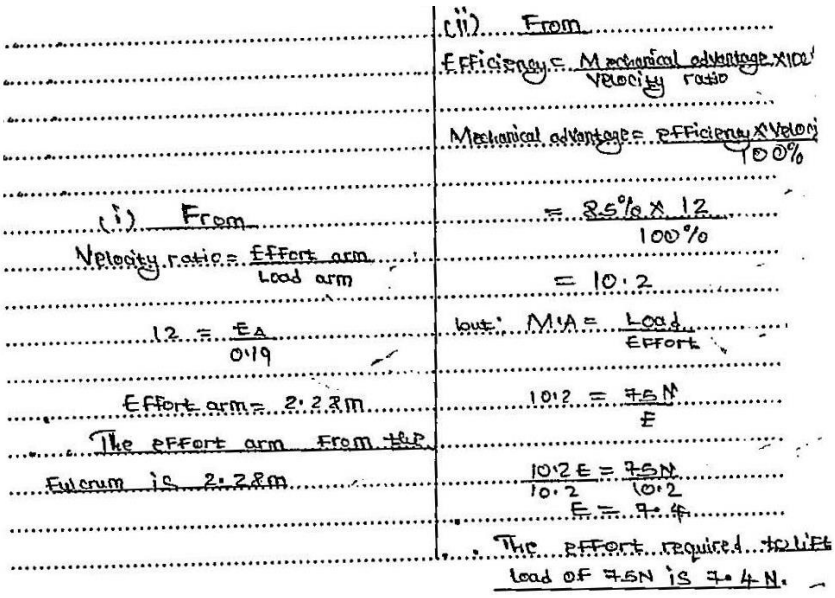
$\frac{600\text{rev/min}}{1000\text{rev/min}} = \frac{\text{Number of teeth D}}{50}$

$\frac{6}{10} = \frac{\text{Number of teeth D}}{50}$

$\frac{10 \times \text{Number of teeth D}}{10} = \frac{50 \times 6}{10}$

Number of teeth D = 30

The number of teeth on wheel D is (30) thirty



Extract 7.2: *A sample of the students' good responses to Question 7*

Extract 7.2 illustrates a sample of good responses from the student who correctly attempted all parts of the question. He/she managed to calculate the number of teeth on wheel D in part (a) and the Effort arm and the effort required in part (b) (i) and (ii), respectively.

2.2.5 Question 8: Electricity and Magnetism

This question consisted of parts (a) and (b). In part (a) the students were required to show that the combined resistance "R_T" is $R_T = R_1 + R_2 + R_3$, Where the three resistors are connected in a series as shown in Figure 3. In part (b), the students were required to sketch a circuit diagram in part (i) and calculate the current recorded by the ammeter when five cells of 2V each and internal resistance of 0.2Ω connected in series with an ammeter and a resistor of 2Ω and filament lamp of 0.5Ω in part (ii).

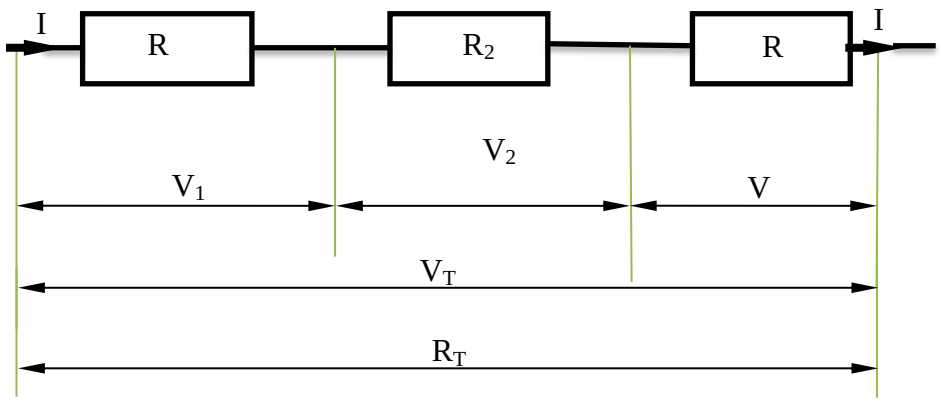


Figure 3

This question was attempted by 1585 (93.6%) students. Among them, 954 (60.2 %) students scored from 0 to 2.5 marks; and 428 (27.0%) students scored from 3 to 6; and the remaining 203 (12.8%) students scored from 6.5 to 10 marks. This shows that the performance on this question was average since 39.8 percent of the students scored from 3 to 10 marks. Figure 9 illustrate the students' scores.

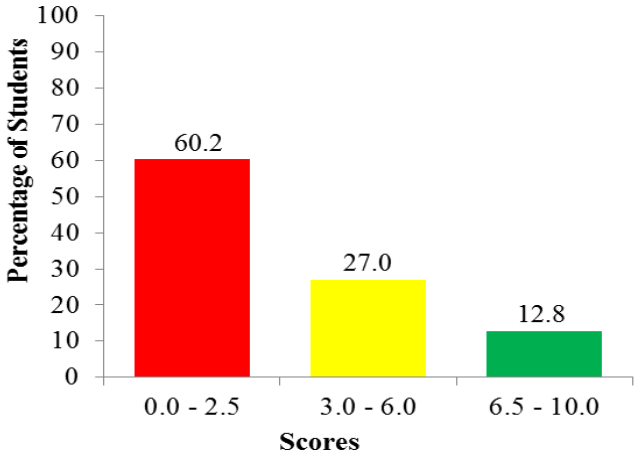


Figure 9: *Students' Performance on Question 8*

The analysis shows that the majority of the students (60.2%) failed to derive the equivalent total resistance for the three resistors connected in series in part (a). They failed to recognize that, whenever there is a flow of charge or the electric current in series, the same current must flow through all resistances and other components sequentially. They also failed to apply Ohm's law to calculate the total voltage changes in individual resistors in a series. They did not understand that according to Ohm's law, the voltage drop, V, across the resistor when the current flows through is calculated by

using the equation V=IR, where I is current in amps (A) and R is the resistance in ohms (Ω). With this relation, the students could find that the voltage drop across R_1 is $V_1=IR_1$, across R_2 is $V_2=IR_2$, and across R_3 is $V_3=IR_3$. Therefore the sum of the voltages would be equal to $V = V_1+V_2+V_3$, and then substituting the value of 'V', they could obtain $V=IR_1+IR_2+IR_3$,$V=IR_1+IR_2+IR_3$ or $V=I(R_1+R_2+R_3)V=I(R_1+R_2+R_3)$. They were supposed to state that the total resistance in a series is equal to the sum of the individual resistances. Therefore, for every circuit with *N* number of resistors connected in a series: $R_{Total\ of\ N}$ (series) = $R_1+R_2+R_3+\ldots+R_N$. In part (b), they failed to sketche of diagrams of the circuits comprising five cells of 2V each, internal resistance of 0.2Ω, an ammeter of 2Ω and a filament lamp of 0.5Ω.

A further analysis on the students' responses revealed that, in part (b)(i), they failed to demonstrate their skills through sketching an electric circuit of five cells with internal resistances as were connected in a series with an ammeter of a negligible resistance, a 2.0 Ω resistor and a filament lamp of resistance 0.5 Ω. They also failed to calculate the current recorded by the ammeter in part (b) (ii). The students' responses show that they lacked adequate knowledge about series and parallel arrangement of resistors. Extract 8.1 is a poor responses to the question.

8. (a) Figure 3 shows three resistors R_1, R_2 and R_3 in Ohms and connected in series so that the same current (I) in Amperes flows. If R_T is the combined resistance and V_T in Volts is the total potential difference across the combined resistance R_T;
Show that $R_T = R_1+R_2+R_3$.

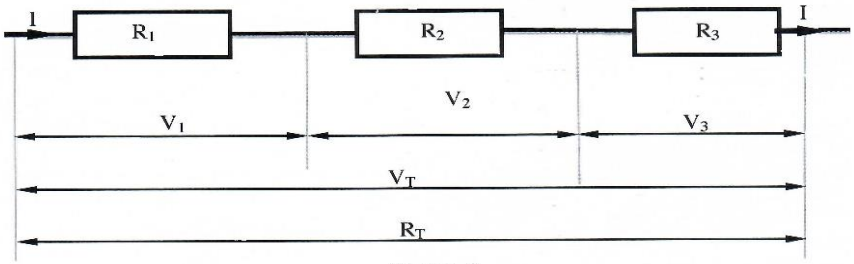


Figure 3

$\frac{R_1, R_2, R_3}{V_1, V_2, V_3} = \frac{V_T}{R_T}$

$= R_T = R_1 + R_2 + R_3$

$= V_T = V_1 + V_2 + V_3$

= Current (I) = Amperes

$= V_T$ = Volts

$\frac{R_T}{V_T} = \frac{R\ V_1 + V_2 + V_3}{R_1 + R_2 + R_3}$

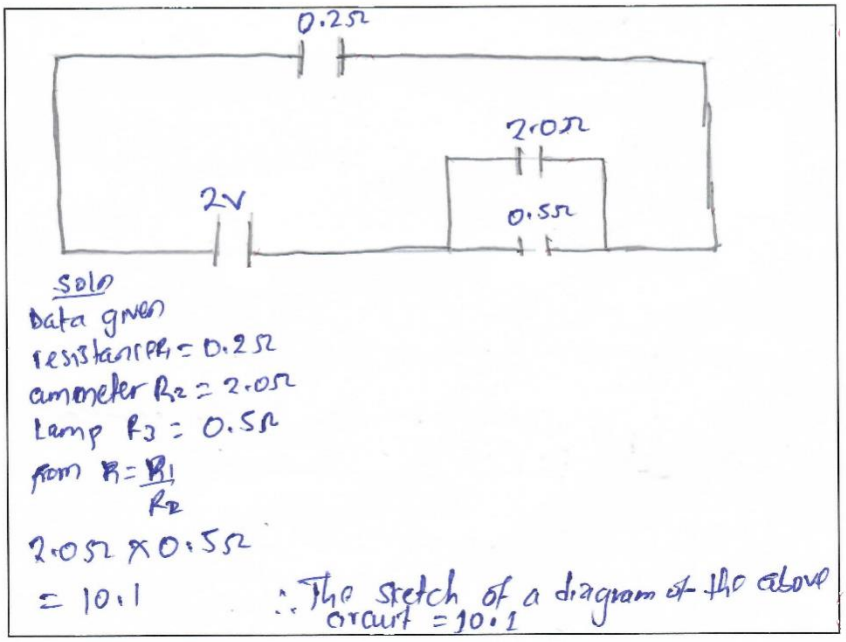
$= V_3, R_2 + V_2, R_2 + V_1, R_1$

∴ The total potential difference across the combined resistance R_T to the show that $R_T = R_1 + R_2 + R_3$

$= V_1 + V_2 + V_3$

(b) Five cells each of e.m.f. 2 V and internal resistance of 0.2 Ω are connected in series with an ammeter of negligible resistance, a 2.0 Ω resistor and a filament lamp of resistance 0.5 Ω.

(i) Sketch of a diagram of the above circuit.



Solo

Data given

resistance $R_1 = 0.2\Omega$

ammeter $R_2 = 2.0\Omega$

Lamp $R_3 = 0.5\Omega$

from $R = \frac{R_1}{R_2}$

$2.0\Omega \times 0.5\Omega$

$= 10.1$

∴ The sketch of a diagram of the above circuit $= 10.1$

Extracts 8.1 is a sample of the poor responses to the question.

Extract 8.1 is a sample of the poor responses presented by the student who wrote irrelevant answers due to inadequate knowledge or circuits of electric currents.

Besides the majority failed to attempt this question correctly, few students (39.8%) scored 3 marks and above. They managed to attempt correctly part (a) or part (b). Therefore, they scored average marks. For example, in part (a) some of the students knew that to derive equivalent resistance for three resistors in a series, Ohm's law must be applied. They stated that

voltage drop V across a resistor when a current flows through it is calculated by using the equation V=IR. These students applied this relation to find the voltage drop across resistors R1, R2 and R3. They substituted the result in the expression V = V1+V2+V3 and obtained IRT=IR1+IR2+IR3, which is equal to IRT =I(R1+R2+R3). Therefore, these procedures led them to score average marks. Those who attempted part (b) managed to sketch only an electric circuit of five cells with internal resistance, an ammeter of negligible resistance, a 2.0 Ω resistor and a filament lamp of resistance 0.5 Ω. They calculated correctly the current recorded by the ammeter. Their responses showed that they had enough knowledge and skills in analyzing series and parallel arrangements of resistors.

On the other hand, the analysis shows that few (12.8%) students scored high marks (6.5 to 10). They correctly calculated and sketched circuit.

They used Ohm's law, the expression V = IR, to obtain the equation of the correct equivalent resistance (RT = R1+R2+R3). In part (b) (i), the students sketched a diagram which represented the circuit of five cells each of e.m.f. 2 V and internal resistance of 0.2 Ω, which were connected in series with an ammeter of negligible resistance of a 2.0 Ω resistor and a filament lamp of 0.5 Ω. In part (b) (ii), the students managed to sketch an electric diagram with all required electrical components and to calculate the amount of current recorded by the ammeter in part (b) (ii). The students had skills, knowledge and understanding to analyse the series arrangement of resistors. Extract 8.2 illustrate such good responses.

8. (a) Figure 3 shows three resistors R_1, R_2 and R_3 in Ohms and connected in series so that the same current (I) in Amperes flows. If R_T is the combined resistance and V_T in Volts is the total potential difference across the combined resistance R_T;
Show that $R_T = R_1+R_2+R_3$.

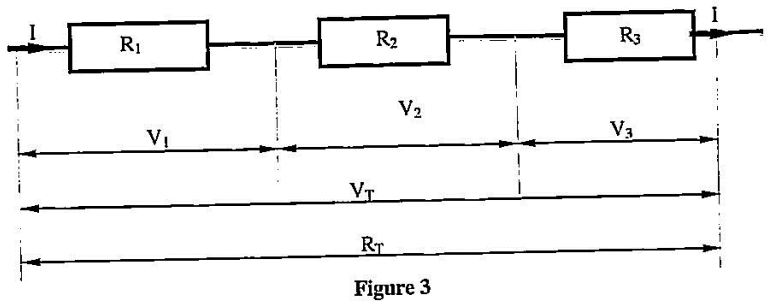


Figure 3

Soln

From, Ohm's law, $V = IR$

Therefore, according to the circuit above,

$V_1 = IR_1$

$V_2 = IR_2$

$V_3 = IR_3$

Note: The current (I) is the same in series circuit.

∴ Total voltage $(V_T) = V_1 + V_2 + V_3$

$V_T = IR_1 + IR_2 + IR_3$

But according to Ohms law,

$V = IR \Rightarrow V_T = IR_T$

$IR_T = IR_1 + IR_2 + IR_3$

Since (I) is common let is be factored out

8.(a)

$I(R_T) = I(R_1 + R_2 + R_3)$

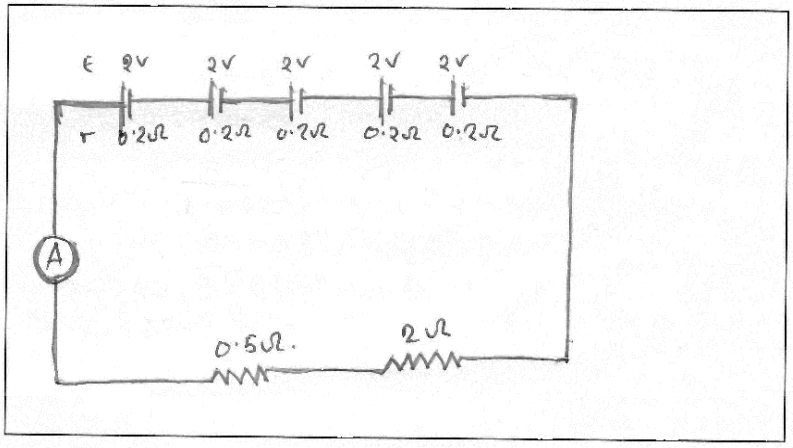
$\frac{I(R_T)}{I} = \frac{I(R_1 + R_2 + R_3)}{I}$

$\therefore R_T = R_1 + R_2 + R_3$

∴ Hence shown that $R_T = R_1 + R_2 + R_3$

(b) Five cells each of e.m.f. 2 V and internal resistance of 0.2 Ω are connected in series with an ammeter of negligible resistance, a 2.0 Ω resistor and a filament lamp of resistance 0.5 Ω.

(i) Sketch of a diagram of the above circuit.



(ii) Calculate the current recorded by the ammeter.

From
$E = I(R+r)$
Data given
$E = 10V$
$R = 2.5\Omega$
$r = 0.8\Omega$
$I = ?$

So
$E = I(R+r)$
$10 = I(2.5+1)$
$10 = I \times 3.5$
$I = \frac{10}{3.5}$
$I = 2.857$ or 2.86

∴ Current recorded is $2.86A$

Extract 8.2: *A sample of the students' good responses to Question 8*

Extract 8.2 is a sample of good responses from one of the students who verified correctly the solution to obtain the equivalent resistance of three resistors R1, R2 and R3, as connected in series in part (a). He/she sketched

the required electric circuit and calculated correctly the current recorded by the ammeter as per part (b) of the question.

2.2.6 Question 9: Linear Motion

The question had parts (a) and (b). Part (b) was comprised of sub parts (i) and (ii). In part (a), the students were required to draw ta velocity-time graph to represent the journey of the car. Part (b) required the students to use the velocity-time graph obtained in part (a) to find the distance covered while the velocity changes from 20m/s to 40m/s in (i) and to find the total distance covered in this journey in (ii).

This question was attempted by 1549 (91.5%) students. Among them, 1092 (70.5 %) students scored from 0 to 2.5 marks; 187 (12.1%) students scored from 3 to 6 marks; and 270 (17.4%) students scored from 6.5 to 10 marks. The general performance on this question was weak as only 29.5 percent of students scored 3 to 10 marks. Figure 10 illustrate the students' scores on this question.

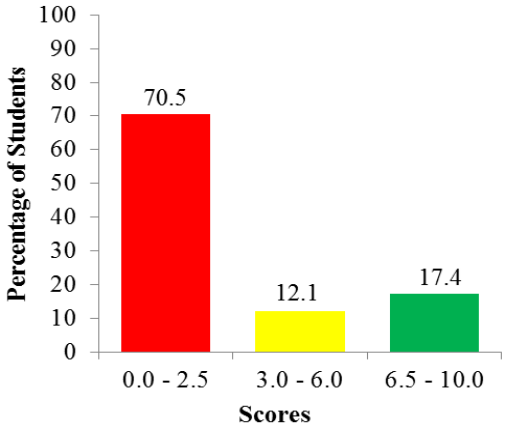


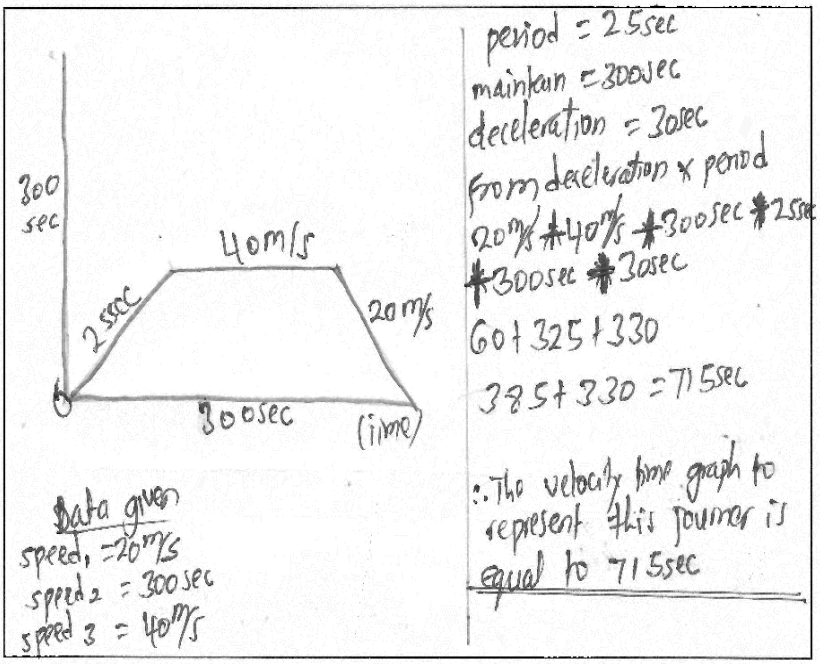
Figure 10: *Students' performance on Question 9*

The students who performed poorly on this question had inadequate knowledge of the concept of linear motion. They failed to give the correct answers to most parts of the question. They failed to draw the velocity-time graph. Their responses indicated that they did not realise that the area of the velocity-time graph represents the journey of a car. Their responses revealed that they lacked skills to sketch a graph of motion. In part (b) (i), the majority of the students failed to interpret the requirements of the question to calculate the area under the graph. They did not know that the

graph drawn in part (a) had to be used in finding the distance covered while the velocity changes from 20 m/s to 40 m/s in part (b)(i) and the total distance covered in this journey in part (b)(ii). Extract 9.1 shows a sample of poor responses from a student who failed to attempt Question 9.

9. A car runs at a constant speed of 20 m/s for 300sec and then accelerates uniformly to a speed of 40 m/s over a period of 25sec. This speed is maintained for 300sec before the car is brought to rest with uniform deceleration in 30 sec.

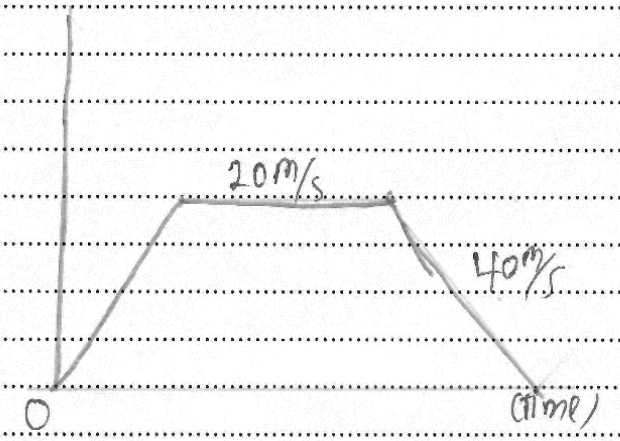
(a) Draw the velocity time graph to represent this journey.



(b) From the graph, find:

(i) The distance covered while the velocity changes from 20 m/s to 40m/s.

(ii) The total distance covered in this journey.



From to the charges = $20^{m/s} \times 40^{m/s}$

about the charges = $20^{m/s} \times 40^{m/s}$

$20^{m/s}$

$\times \underline{40^{m/s}}$

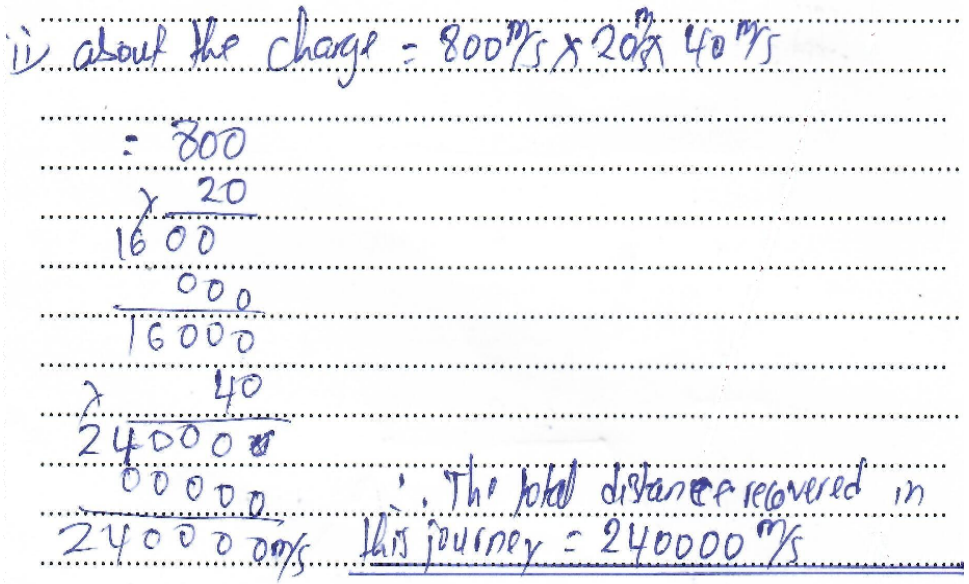
$80^{m/s}$

00

800

$= 800^{m/s}$

∴ The distance covered while the velocity charge from $20^{m/s}$ to $40^{m/s} = 800^{m/s}$



Extract 9.1: *A sample of students' poor responses to Question 9*

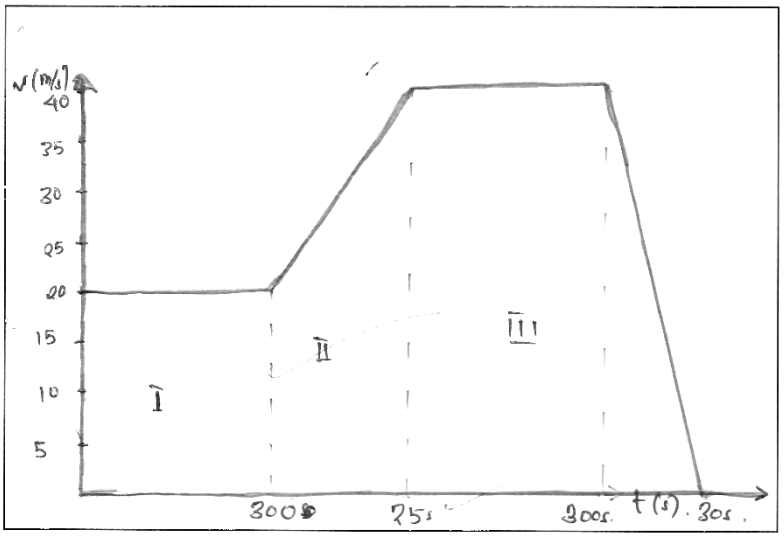
Extract 9.1 illustrates a sample poor responses to all parts of the question. the student drew incorrect velocity-time graph and used wrong approach to find the distance covered while the velocity changed from 20 m/s to 40 m/s in part (b)(i) and the total distance covered from 0 s to 655 s in part (b)(ii).

Despite the poor performance of the students on this question, some of students managed to perform averagely. They had some knowledge of the concept of linear motion, especially to use the data given in part (a) to correctly draw the required velocity-time graph. Furthermore, they managed to find the distance covered as the velocity changed from 20 m/s to 40 m/s in part (b)(i). However, they failed to compute the total distance covered in this journey in part (b)(ii). They summed the three parts of the graph instead of calculating the summation of the distance covered during the acceleration which attained the speed of 40m/s over a period of 25sec and that of uniform retardation in 30sec. These students did not understand that the distance covered involves the whole area under the velocity-time graph. They lacked adquate knowledge of interpreting the graph with respect to area and distances covered.

In contrast, the students who performed this question well had adequate knowledge of the concept of linear motion. Some of them correctly drew the velocity time graph in part (a) and clearly understood the requirements

of the question. Hence, they correctly calculated the areas of different portions under the graph and obtained the distance covered when the velocity changed from 20 m/s to 40 m/s in part (a)(i). Moreover, these students calculated the total distance covered by correctly adding up the areas obtained from the portions of the velocity-time graph. Extract 9.2 shows a good response from the student who attempted the question well.

9. A car runs at a constant speed of 20 m/s for 300sec and then accelerates uniformly to a speed of 40 m/s over a period of 25sec. This speed is maintained for 300sec before the car is brought to rest with uniform deceleration in 30 sec.
   (a) Draw the velocity time graph to represent this journey.



   (b) From the graph, find:
   (i) The distance covered while the velocity changes from 20 m/s to 40m/s.
   (ii) The total distance covered in this journey.

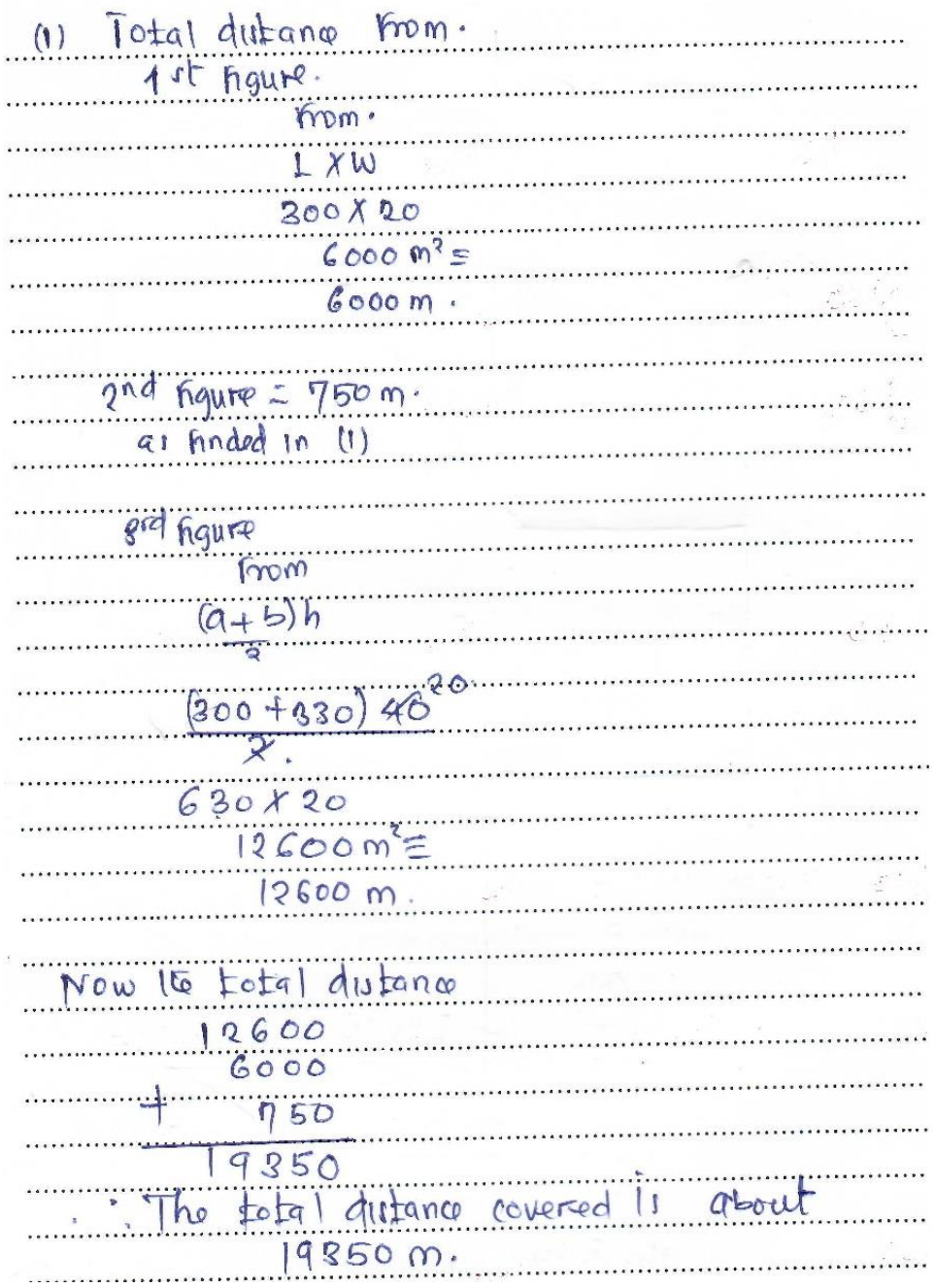
(i) Soln.

from $\frac{(a+b)h}{2}$ $\frac{(20+40)25}{2}$

$\frac{60 \times 25}{2} = 30 \times 25$

$750 m^2$

∴ The distance covered while the velocity change from 20 m/s to 40m/s is 750 m.



Extract 9.2: *A sample of the student's good responses to Question 9*

Extract 9.2 is a sample of the good responses to the good. The student correctly drew the velocity-time graph and used it to find the distance covered when the velocity changed from 20 m/s to 40 m/s in part (b)(i) and the total distance covered throughout the journey in part (b)(ii).

2.2.7 Question 10: Turning Forces

The question stated as follows:

(a) Figure 4 shows a beam balance acted upon by several forces. What assumption is to be made in order to compute moments of several forces acting on a beam?

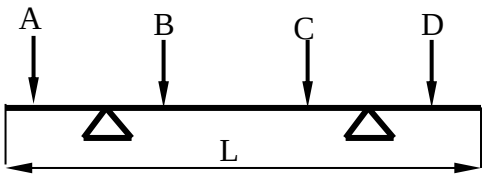


Figure 4

(b) In a school laboratory, there is a uniform wooden lath 100 cm long and of mass 90 g designed to balance on a knife-edge when a 10 g mass is hung 10 cm from one end. With the aid of sketch determine how far is the knife-edge from the centre of the lath?

The question was attempted by 1413 (83.5%) students, whose scores were as follows: 1069 (75.7%) students scored from 0 to 2.5 marks; 324 (22.9 %) students scored from 3 to 6 marks; and 20 (1.4%) students scored from 6.5 to 10 marks. The general performance on this question was weak. Figure 11 illustrates the students' scores.

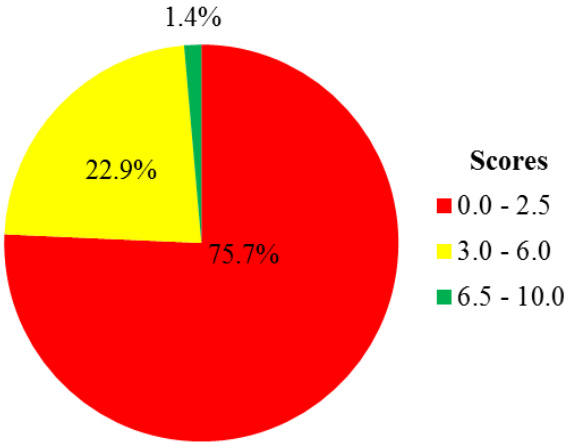


Figure 11: *Student's performance on Question 10*

There were 75.7 percent of the students who scored low (0 to 2.5) as they marks provided incorrect answers to most parts of the question. Some of

the students lacked adequate knowledge about the basic concept of forces in equilibrium. They thus failed to state the assumption in order to compute moments of several forces acting on a beam in part (a). They did not understand that the assumption is that the weight of the rule could concentrate or act at the centre of the beam, and the clockwise moment is equal to the anti-clockwise moment. They also failed to sketch and present the forces acting on the uniform wooden lath in part (b); accordingly, they failed to calculate the distance from the centre of the lath to the knife edge. The students did not interpret and transform the data given in the question to a sketch due to their lack of skills in sketching. Consequently, they failed to calculate the distance of the knife-edge from the center of the lath because they could not provide relevant sketches which would help them to compute the distance of the knife-edge from the centre of the lath. Extract 10.1 shows a sample of the poor responses to the question.

10. (a) Figure 4 shows a beam balance acted upon by several forces. What assumption is to be made in order to compute moments of several forces acting on a beam?

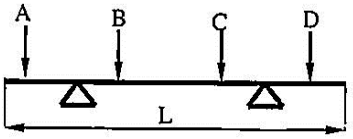


Figure 4

Fulcum = Load
Effort
∴ = Papendulum assumption.

(b) In a school laboratory, there is a uniform wooden lath 100 cm long and of mass 90 g designed to balance on a knife-edge when a 10 g mass is hung 10 cm from one end. With the aid of sketch, determine how far is the knife - edge from the centre of the lath?

'Data given
Work = mass = 90 g
Distance = 100cm
Work done = Mass
Distance
W. done = 10
110
∴ Work done = 10/11
∴ work done = 1.1 m/s

Extract 10.1: *A sample of students' poor responses to Question 10*

Extract 10.1 shows a sample of the poor responses from a student who confused moment of forces with that of mechanical advantages of the lever in a simple machine. Instead of stating the assumption related to moments of several forces acting on a beam, he/she wrote irrelevant formula for the simple machine topic. He/she confused the diagram of a beam balance in Figure 4 with that of three classes of lever. He/she also failed to sketch and determine the distance from the centre of the lath to the point of a knife–edge.

Only 22.9 percent of the students scored average (3 to 6) marks on this question because they attempted some parts of the question. Some of them stated the correct assumption to be made in order to compute moments of several forces acting on the beam in part (a) and sketched the forces acting on the uniform wooden lath in part (b), but they failed to use the calculation procedures to obtain the distance required. Others attempted part (b) only by sketching the required diagram of forces or did some calculation procedures but failed to obtain the correct answer. Therefore, they scored average marks on this question.

A further analysis shows that 1.4 percent of all students scored high (6.5 to 10) marks on this question. These students managed to attempt part (b) by writing the formula of *clockwise moment = ant-clockwise moment* and

managed to go through all calculation steps to obtain the required answer. Hence, they scored full marks. Others answered part (a) correctly and partly attempted part (b). As a result they scored good marks.

The students who scored full (10) marks demonstrated a good mastery of the concept of the forces in equilibrium as they correctly stated the assumption made in order to compute moments of several forces acting on a beam. These students had skills of interpreting and transforming the data given in the question into a sketch to represent the uniform wooden lath on which it was acted upon by a several forces. They also managed to compute the distance from the centre of the lath to the point at which the knife-edge balanced the wooden lath. Their responses showed the students had adequate knowledge about the concept of the turning force and moments of force. Extract 10.2 is a sample of correct responses to this question.

10. (a) Figure 4 shows a beam balance acted upon by several forces. What assumption is to be made in order to compute moments of several forces acting on a beam?

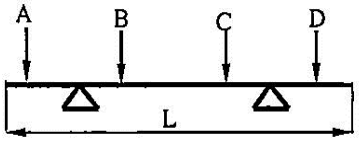
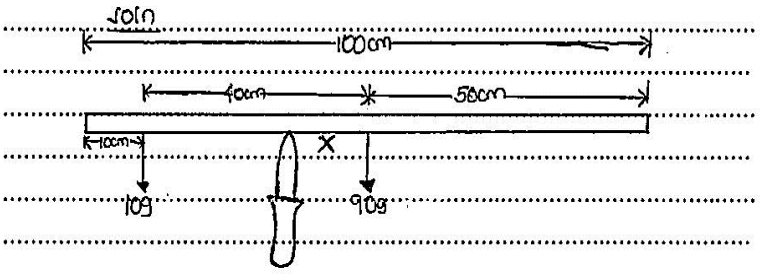


Figure 4

- First assumption will be that " total clockwise Moments will be equal to the total anticlockwise Moments ".

- Second assumption will be that " sum of upward forces must be equal to the sum of downward forces ".

(b) In a school laboratory, there is a uniform wooden lath 100 cm long and of mass 90 g designed to balance on a knife-edge when a 10 g mass is hung 10 cm from one end. With the aid of sketch, determine how far is the knife - edge from the centre of the lath?



"If from 90g to the knife is X then from 10g to the edge of the knife will be 40cm - X"

Then,

from,

Clockwise moments = anticlockwise moments

$90gX \times x = 10g(40cm - x)$

$90gx = 400gcm - 10gx$

$90gx + 10gx = 400gcm$

$100gx = 400gcm$

$\frac{100gx}{10.0g} = \frac{400gcm}{100g}$

$X = 4cm$

∴ Then, there are 4cm from the edge of knife to centre of the lath.

Extract 10.2: *A sample of students' good responses to Question 10*

Extract 10.2 shows a sample of the responses from a student who had adequate knowledge of the concept of moment of forces. He/she managed to state the correct assumption made in order to compute moments of several forces acting on a beam. He/she correctly wrote the relationship of clockwise and anti-clockwise moments to determine the distance from the centre of the lath to the point of the knife-edge and followed all calculation procedures to obtain the correct answer.

3.0 THE STUDENTS' PERFOMANCE ON EACH TOPIC

The Engineering Science paper had ten (10) questions set from various topics of form I and form II. The analysis of the performance shows that the students demonstrated good performance on questions 2, 1 and 3 since the percentages of the students who passed were 97.8, 91.0 and 75.3 respectively. Question 2 was a True and False question set from topics of *Work, Energy and Power, Unit and Measurement, Simple Machine, Fluid Mechanics, Heat, Electricity and Magnetism*, *Sound and Friction*. Question 1 was multiple choice question set from the topics of *Heat, Simple Machine, Force, Sound, Light, Electricity and Magnetism, Linear Motion*, *Unit and Measurement* and Question 3 was set from the topics of *Sound, Work, Energy and Power*, *Simple Machine, Heat, Light, Turning Force*, *Friction, Linear Motion and Force*.

The topics on which the learner performed averagely are *Light* (62.0%), *Electricity* and *Magnetism (*39.8%*), Fluid Mechanics* (36.0%) and *Simple Machine* (35.4%).

Furthermore, the analysis shows that the students had poor performance on the remaining three (3) questions as most of them scored below 30 percent on each question. These questions were constructed from the topic of *Linear Motion* (29.5%), *Turning Force* (24.3%) and *Work, Energy and Power* (14%). Appendix 1 summarizes the students' performance on each topic using red, yellow and green colours to represent weak, average and good performance levels, respectively.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

In general, the performance in the Engineering Science subject was average since 808 (47.8%) students passed. Most of them had average and good performance on seven (7) questions and weak performance on three (3) questions. However, most students had a relatively higher performance on objective questions than on subjective questions.

The good performance in some questions was mainly caused by students' adequate knowledge of the topics from which the questions were derived, ability to recall laws, principle and formula understand the demands of the questions as well as express well when responding to the questions. However, inadequate knowledge of the subject matter, poor calculation and drawing skills and language barrier hindered some students from scoring higher marks on some questions.

4.2 Recommendations

To improve students' performance, this report recommends the following:

(a) Students should be guided and encouraged to read various and relevant Engineering Science materials (books, journals and pamphlets) to broaden their knowledge and skills

(b) Teachers should guide the students through practicing how to identify the requirements of the question(s).

(c) For the poorly performed topics, teachers should use relevant teaching/learning materials and aids, valid references as well as consider the level of the learners' knowledge, skills and experiences.

(d) Improvement of learning and teaching processes in schools calls for the cooperation and unified efforts of students, teachers, school heads, education quality assurers and other education stakeholders in readressing the weaknesses identified herein.

Appendix I

A Summary of Students' Performance (Question-wise) in the Engineering Science Subject

S/N	Topic	Scored of each Question		Percentage of students who scored 30 percent or more	Recommendation
		Question Number	Scores (%)		
1	Work, Energy and Power, Unit and Measurement, Simple Machine, Fluid Mechanics, Heat, Electricity and Magnetism, Sound and Friction.	2	97.8	97.8	Good
2	Heat, Simple Machine, Force, Sound, Light, Electricity and Magnetism, Linear Motion, Unit and Measurement.	1	91.0	91.0	Good
3	Sound, Work, Energy and Power, Simple Machine, Heat, Light, Turning Force, Friction, Linear Motion and Force.	3	75.3	75.3	Good
4	Light	6	62.0	62.0	Average
5	Electricity and Magnetism	8	39.8	39.8	Average
6	Fluid Mechanics	4	36.0	36.0	Average
7	Simple Machine	7	35.4	35.4	Average
8	Linear Motion	9	29.5	29.5	Weak
9	Turning Force	10	24.3	24.3	Weak
10	Work, Energy and Power	5	14	14	Weak