Item Discrimination and Distractor Analysis: A Technical Report on Thirty Multiple Choice Core Mathematics Achievement Test Items

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Abstract:- **The report focused on providing a detailed analysis with respect to item discrimination and distractor analysis of a thirty core mathematics achievement test.The test measured senior high school students' achievement in core mathematics on some specific areas they were taught. After the discrimination and distractor analysis, it was found that 27 out of the 30 items discriminated positively, 2 discriminated negatively and 1 had a zero discrimination. The distractor analysis of all the options of the 30 items were also computed and discussed.**

Keywords: **Item discrimination, distractor analysis, item analysis**

I. INTRODUCTION

The test (see appendix A) was conducted at a senior high school in the Northern Region of Ghana. The purpose of the test was to measure senior high school students' achievement in core mathematics after they have been taught successfully in the following areas; linear equations, linear inequalities, simultaneous equations, percentages, vectors and indices. Thirty items on the areas listed above were crafted by their teachers and in each of the items, four options were provided for the students to choose the best option as an answer. The test was administered and scored by the assessors (teachers), following strictly the scoring rubric prepared.

According to Mehrens and Lehmann (as cited in Amedahe & Asamoah-Gyimah 2016), item analysis refers to the process of examining students' responses to each item to judge the quality of the items. Crocker and Algina (1986) point that distractor analysis can be a tedious task which demands high level of professionalism and expertise and that, as part of item analysis, emphasis are always placed on item difficulty to the neglect of item discrimination and distractor analysis due to their (item discrimination and distractor analysis) nature (Crocker & Algina, 1986). In particular, distractor analysis is an extension of item analysis using techniques that are similar to item difficulty and item discrimination. In distractor analysis, we are no longer interested in how the test takers select the correct answer, but how the distractors were able to function effectively by drawing the test takers away from the correct answer (Crocker &Algina, 1986). The number of times each distractor is selected is noted in order to determine the effectiveness of the distractor. A test expert would expect that the distractor is selected by enough of the low achieving candidates for it to be effective and viable distractor. In analysing the effectiveness of the distractors, both the item difficulty and item discrimination index can be used but in this regard, the item discrimination index was used from a different perspective.

Before the distractor analysis, the discrimination index of the items were first calculated. According to Amedahe and Asamoah-Gyimah (2016), the discrimination power of a test item is its ability to differentiate between pupils who have achieved well (the upper group) and those who have achieved poorly (the lower group). The purpose of the discrimination index is to tell the assessor if an item really is showing differences between capable students and less capable students (Amedahe & Asamoah-Gyimah, 2016). In determining the discrimination index, 27% of the total number of students who took the test was computed. That is, $\frac{27}{100} \times 37 = 9.99 \approx 10$ students.The scores were arranged from the highest to the lowest and 10 scripts were counted starting from the highest scores to form the upper group whereas another 10 scripts were counted from the bottom of the lowest scores to form the lower group leaving the middle group of 17 scripts.

For each of the item, the discrimination index was computed by subtracting the number of students in lower group who answered the item correctly from the number of students in the upper group who got the item right. The result was therefore divided by the number of students in either group (that is, 10). Specifically, the discrimination index (*D*) was computed by using the formulae: $D = \frac{RU - RL}{N}$, where *RU* refers to the number of students in the upper group who answered the test item correctly, *RL* refers to the number of students in the lower group who answered the test item correctly and *N* is the number of students in any of the two groups. Mathematically, the various discrimination indexes were computed and the discrimination index for item one with RU = 9, RL = 8 and N = 10 is given by: $\frac{9-8}{10} = \frac{1}{10} = 0.1$. Similarly, the discrimination index for item two with RU = 10, RL = 7 and N = 10 is given by: $\frac{10-7}{10} = \frac{3}{10} = 0.3$, discrimination index for the third item is given by $\frac{10-7}{10} = \frac{3}{10} = 0.3$, fourth item is $\frac{9-5}{10} = \frac{4}{10} = 0.4$, item five is $\frac{6-4}{10} = \frac{2}{10} = 0.2$ and sixth items is

given by $\frac{8-5}{10} = \frac{3}{10} = 0.3$ and it is in this regard that the rest of the discrimination indexes for the other items were computed. It should be noted that, although the middle group was made up of 17 students, the emphasis was on the upper and lower groups. The summary is presented in Table 1.

Table 1- Discrimination Index of the Thirty-Item

N = 10

Item	RU	RL	Discrimination Index
1	9	8	0.1
2	10	7	0.3
3	10	7	0.3
4	9	5	0.4
5	6	4	0.2
6	8	5	0.3
7	9	5	0.4
8	2	0	0.2
9	10	9	0.1
10	7	9	-0.2
11	8	6	0.2
12	8	6	0.2
13	8	0	0.8
14	10	8	0.2
15	5	3	0.2
16	4	1	0.3
17	2	2	0.0
18	5	2	0.3
19	6	2	0.4
20	4	4	0.0
21	7	1	0.6
22	3	2	0.1
23	7	3	0.4
24	7	3	0.4
25	9	1	0.8
26	3	1	0.2
27	7	1	0.6
28	9	5	0.4
29	8	3	0.5
30	5	4	0.1

Source: Test analysts, Asamoah & Ocansey (2017)

The value of the item discriminating index is usually expressed as a decimal and ranges from -1.00 to 1.00 (Amedahe & Asamoah-Gyimah, 2016). If the index is a positive value, it means that the item has a positive discrimination. A positive discrimination therefore means that a larger proportion of the more knowledgeable students than the poor students got the item right. From Table 1, all the items apart from 10, 17, and 20 recorded positive discrimination indexes and that shows that majority of the students in the upper group (knowledgeable students) answered the items correctly. This is notable because, as indicated by Crocker and Algina (1986), for an item to be good, majority of the knowledgeable students should be able to get that particular item right than the poor students. Additionally, if the discrimination index of the item is zero, the item has a zero discrimination and that means the item is too easy or too hard and thus, every students got the item right, every student missed the item or the item is ambiguous. In this regard, items 17 and 20 had a zero discrimination indexes (See Table 1). According to Amedahe and Asamoah-Gyimah (2016), an item can have a negative discrimination if the poor or lower group students than the better students get the item right. Any negative value means that the test item discriminates, to some degree, in the wrong direction and thus, the discrimination power of the test item is unsatisfactory. From Table 1, it is clear that item 10 recorded a negative discrimination index of -0.2 which indicates that the poor or lower students had the item right than the upper or knowledgeable students and such a case although discriminates, is unsatisfactory. The summary of items that recorded positive, zero or negative discrimination index is presented in Table 2.

Table 2- Description of Discrimination Power of Items

Description	Items
Positive	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 18, 19, ,21, 22, 23, 24, 25, 26, 27, 28, 29 and 30
Zero	17 and 20
Negative	10

Source: Test analysts, Asamoah &Ocansey (2017)

II. DISTRACTOR ANALYSIS

In analysing the distractors, the concept of upper groups and lower groups were used, but the analysis and expectation differed slightly from the regular item discrimination. Instead of expecting a positive value, we should logically expect a negative value as more students from the lower group should select the distractors. Each distractor can have its own item discrimination value in other to analyse how the distractors work and ultimately refine the effectiveness of the test item itself. The total number of students in the upper and the lower groups was 10. In the analysis, the discrimination index for each of the options was calculated by subtracting the number of students in the lower group who chose the option from the number of students in the upper group who chose the option. Including the keys or the correct answers, the discrimination indexes of the distractors (options) were computed and for example, the discrimination index for the first distractor A, in the first item is given by $\frac{0-1}{10}$ = - 0.1, the second distractor B, in the first item is calculated by $\frac{0-1}{10}$ = -0.1 and the last

distractor C, in the first item is calculated by $\frac{2-0}{10}$ = 0.2. Where 0, 0 and 2 and 1, 1 and 0 were the number of students in the upper and lower groups who chose the distractors respectively and 10 is the number of students in both groups. It is clear that the calculations are the same as calculating the discrimination index. The discrimination index of each of the options are illustrated in the Table 3. The options marked (***) are the keys or correct answers.

Table 3-Discrimination Index of each Distractor and the Keys

N = 10

Distractors	No. of upper group who selected	No. of lower group who selected	Discrimination Index
Item one			
A. 110	0	1	- 0.1
B. 112	0	1	- 0.1
C. 120 ***	8	8	0.0
D. 125	2	0	0.2
Item two			
A. 19	0	1	-0.1
B. 20	0	0	0.0
C. 21 ***	10	7	0.3
D. 23	0	2	- 0.2
Item three			
A. $\{y : y = 3\}$ ***	10	6	0.4
B. $\{y : y \neq 3\}$	0	2	-0.2
C. $\{y : y = -3\}$	0	0	0.0
D. $\{y : y \neq -3\}$	0	2	- 0.2
Item four			
A. 5 years	0	3	-0.3
B. 10 years	0	1	-0.1
C. 20 years ***	9	3	0.6
D. 25 years	1	3	0.2
Item five			
A. $\binom{-2}{-1}$	2	4	-0.3
B. $\binom{-4}{-9}$	2	1	-0.1
C. $\binom{2}{1}$	0	2	0.2
D. $\binom{4}{9}$ ***	6	3	0.1
Item six			
A. – 3	0	0	0.0
B. – 2	1	4	-0.3
C. 2 ***	9	5	0.4
D. 3	0	1	-0.1
Item seven			
A. 28	0	2	-0.2
B. 48 ***	9	5	0.4
C. 84	1	2	-0.1
D. More information is required.	0	1	-0/1
Item 8			
A. $\binom{-3}{-2}$			
B. $\binom{-2}{3}$	0	1	-0.1
C. $\binom{2}{3}$	3	4	-0.1
D. $\binom{3}{2}$ ***	6	5	-0.1
	1	0	0.1
Item 9			
A. – 3	0	0	0.0
B. – 2	0	1	-0.1
C. 2	0	1	-0.1
D. 3 ***	10	8	0.2
Item 10			
A. 60%	2	1	0.1
B. 62% ***	6	8	-0.2
C. 66%	0	1	-0.1
D. 68%	2	0	0.2

Item 11			
A. – 1.3	0	3	-0.3
B. – 1.2	1	0	0.1
C. 1.2	1	2	-0.1
D. 1.3 ***	8	5	0.3
Item 12			
A. $x \geq -16$ ***	8	5	0.3
B. $x \leq -16$	1	2	-0.1
C. $x \geq 16$	0	2	-0.2
D. $x \leq 16$	1	1	0.0
Item 13			
A. 13 years ***	8	1	0.7
B. 16 years	1	3	-0.2
C. 18 years	1	3	-0.2
D. Can't be determined.	0	3	0.3
Item 14			
A. – 3	0	1	-0.1
B. – 2 ***	10	7	0.3
C. 2	0	1	-0.1
D. 3	0	1	-0.1
Item 15			
A. $\left\{x : x < \frac{-17}{11}\right\}$ ***	5	4	0.1
B. $\left\{x : x > \frac{-17}{11}\right\}$	4	5	-0.1
C. $\left\{x : x \leq \frac{-17}{11}\right\}$	1	0	0.1
D. $\left\{x : x \geq \frac{-17}{11}\right\}$	0	1	-0.1
Item 16			
A. $\binom{1}{3}$	0	1	-0.1
B. $\binom{1}{-3}$	4	6	-0.2
C. $\binom{-1}{-3}$	0	3	-0.3
D. $\binom{-3}{-1}$ ***	6	1	0.5
Item 17			
A. $\frac{-17}{6}$ ***	2	2	0.0
B. $\frac{-6}{17}$	0	2	-0.2
C. $\frac{6}{17}$	0	1	-0.1
D. $\frac{17}{6}$	8	5	0.3
Item 18			
A. $ 3,000,000	1	2	-0.1
B. $ 300, 000	2	2	-0.1
C. $ 3,000 ***	5	1	0.4
D. $ 300	2	5	-0.3
Item 19			
A. $ 600,000	0	1	-0.1
B. $ 60, 000	1	3	-0.2
C. $ 6,000	2	4	-0.2
D. $ 600 ***	7	2	0.5
Item 20			
A. $ 12	0	1	-0.1
B. $ 1,200 ***	4	2	0.2
C. $ 120,000	4	5	-0.1
D. $ 1,200,000	2	2	0.0
Item 21			
A. $5k$ ***	7	2	0.5
B. 5^k	2	3	-0.1
C. $25k$	1	3	-0.2
D. 25^k	0	2	-0.2

Item 22 A. $\binom{-4}{-10}$ B. $\binom{-15}{-6}$ *** C. $\binom{-2}{-5}$ D. $\binom{-25}{10}$	4 3 2 1	2 2 4 2	0.2 0.1 -0.2 -0.1
Item 23 A. $\frac{-1}{x}$ B. $-x$ C. x D. $\frac{1}{x}$ ***	1 0 2 7	2 3 1 4	-0.1 -0.3 0.1 0.3
Item 24 A. $\left\{a,b: a=-3,\ b=\frac{1}{2}\right\}$ B. $\left\{a,b: a=\frac{1}{2},\ b=3\right\}$ C. $\left\{a,b: a=3,\ b=\frac{1}{2}\right\}$ *** D. $\{a,b: a=3,\ b=\frac{-1}{2}\}$	0 2 7 1	2 3 3 2	-0.2 -0.1 0.4 -0.1
Item 25 A. $\binom{1}{-4}$and$\binom{5-x}{4-y}$ *** B. $\binom{-4}{1}$ and$\binom{5-x}{4-y}$ C. $\binom{-4}{-1}$ and$\binom{4-y}{5-x}$ D. $\binom{-1}{-4}$and$\binom{5+x}{4+y}$	9 0 0 1	2 3 2 3	0.5 -0.3 -0.2 -0.2
Item 26 A. $x=-4$ and $y=-8$ B. $x=-8$ and $y=-4$ C. $x=8$ and $y=4$ D. $x=4$ and $y=8$ ***	1 0 3 6	3 2 4 1	-0.2 -0.2 -0.1 0.5
Item 27 A. $\sqrt{5}$ units B. $\sqrt{7}$ units C. $\sqrt{12}$ units D. $\sqrt{13}$ units ***	1 1 1 7	2 4 2 2	-0.1 -0.3 -0.1 0.5
Item 28 A. -6 *** B. -4 C. 2 D. 6	9 0 1 0	5 1 2 2	0.4 -0.1 -0.1 -0.2
Item 29 A. $x=\{-4,-3,-2,-1,0,1,2\}$ B. $x=\{-3,-2,-1,0,1\}$ *** C. $x=\{-2,-1,0,1,2\}$ D. $x=\{-4,\ 2\}$	0 8 0 2	1 5 3 2	-0.1 0.3 -0.3 0.0
Item 30 A. $\binom{3}{0}$ B. $\binom{6}{4}$ C. $\binom{10}{4}$ *** D. $\binom{10}{7}$	2 0 5 3	2 2 6 1	0.0 -0.2 -0.1 0.2

Source: Test analysts, Asamoah & Ocansey (2017)

All the discrimination indexes of all the options are shown above to evaluate the effectiveness of each of the distractors apart from the keys (See table 3). A distractor that recorded a negative discrimination index is effective and desirable and

that means that such distractor was plausible enough to attract the uninformed (Haladyna, Downing & Rodriguez, 2002).

With regards to the first item, alternative C was the key and a discrimination index of 0.0 means that the alternative did not discriminate between the upper and the lower group students. The values for distractors A and B seemed to have functioned effectively because more of the students in the lower group chose these alternatives (-0.1, -0.1). On the other hand, the distractor D recorded a positive discrimination index which is not desirable because more of the students in the upper group chose the alternative than the students in the lower group and hence, the distractor D was not effective (See Table 3). For item two, the alternative C was the key which recorded a positive discrimination value (0.3) and that is what we want although the value 0.3 is low considering the maximum value of 1. 0. But it is clear that distractors A and D functioned effectively because more of the lower students chose the distractors. Meanwhile the distractor B obtained a value of 0.0 and that means the distractor did not discriminate between the upper group and the lower group and hence, the effectiveness of the distractor is questionable.

For the third item, the alternative A was the key and it is desirable because it recorded a discrimination value of 0.4. Alternatives B and D functioned effectively and were plausible to the uninformed because negative discrimination indexes were obtained (See Table 3) whereas distractor B did not discriminate the students (value of 0.0). With regards to item four, alternative C was the key which was very desirable (value of 0.6) because more of the upper group students chose the alternative. Meanwhile, distractors A and B were effective (-0.3, -0.1) whiles distractor D was not effective because it attracted the upper group students than the lower group (value of 0.2). In the fifth item, distractors A and B were effective (-0.3, -0.1), distractor C was not effective (value of 0.2) and the key which was alternative D was desirable but not good enough (value of 0.10).

In the sixth item, alternative C was the key and it was desirable (value of 0.40), distractors B and D functioned effectively while distractor A did not discriminate and hence, it was ineffective (See Table 3). The key for item seven was B which was desirable (value of (0.40), the distractors A, C and D were effective and attracted the lower group students (-0.2, -0.1 and -0.1). with regards to item eight, the key was alternative D which was desirable but the discrimination index was very low (0.1). The distractors A, B and C were all effective (-0.1, -0.1, and -0.1,). Effective distractors in item nine were B and C (-0.1, -0.1,), distractor A was not effective because it did not discriminate (value of 0.0). The key for the item nine was D. In item ten, the effective distractor was alternative C. distractors A and D were not effective because the upper group students chose the alternatives (0.1, 0.2). Meanwhile the key for the item was alternative B which recorded a negative discrimination index and that means more students in the lower group chose the alternative which is undesirable.

In the eleventh item, the alternative D was the key which was desirable (0.3), distractors A and C were effective and plausible (See Table 3) whereas distractor B was not effective (value of 0.1). Effective distractors in item twelve were B and C (values of -.01, -.02) whereas distractor D was not effective (value of 0.0). In item thirteen, the alternative A was the key which was very desirable (value of 0.7), distractors B, C and D functioned well and were effective (values of -0.2, -.02 and -0.3). The key for item fourteen was alternative B which was what the assessor was looking for (value of 0.3) although low, all the distractor A, C and D were plausible and effective (-0.1, -0.1, and -0.1). In item fifteen, the key was alternative A (value of 0.1) and positive value is good, distractors B and D were effective (-0.1, -0.1) whereas distractor C was not effective (0.1). All the distractors in item sixteen functioned well and were effective (-0.1, -0.2 and -0.3) and the key for the item was D (value of 0.5) which was very good. Distractors B and C in item seventeen were effective because the distractors recorded a negative value whereas distractor D was not effective because of a positive figure recorded (See Table 3). The key for the item was alternative A. Similarly, in item eighteen, all the distractors were effective and attracted the lower group students with alternative C as the key which was desirable (See Table 3).

In item nineteen, the alternative D was the key which recorded a positive discrimination value, all the distractors functioned well and were effective distractors (See Table 3). The effective distractors regarding item twenty were A and C because they recorded a negative discrimination value, distractor D failed to discriminate and thus, it was ineffective. The key for the item was B which is desirable (See Table 3). In item twenty-one all the distractors were effective and the key for the item was A which was desirable because the discrimination index for alternative A was 0.5 (See Table 3). Effective distractors in item twenty-two were C and D, distractor A was not effective and the key for the item was B which was desirable (See Table 3). The key for item twenty-three was D which recorded a positive discrimination index, effective distractors were A and B and distractor C was not effective (See Table 3). In item twenty-four, all the distractors were effective and the key for the item was alternative D which was desirable and the same occurred in item twenty-five with alternative A as the key which obtained a positive discrimination index (See Table 3). In items twenty-six, twenty-seven and twenty-eight, all the distractors were effective. The keys for the items twenty-sixth and twenty-seventh was D in each case for the two items and A for twenty-eight which were desirable because a positive discrimination indexes were obtained (See Table 3). The distractors in items twenty-six, twenty-seven and twenty-eight were all effective because a negative discrimination indexes were obtained (See Table 3). In item twenty-nine, the alternative B was the key which recorded a positive discrimination index which is desirable. Effective distractors were A and C. The distractor D was not effective because it did not discriminate (See Table 3). In last item, the key was

alternative C, effective distractors were alternatives B and C leaving the distractor D ineffective (See Table 3).

III. CONCLUSION

Developing a perfect test is an unattainable goal for everyone in evaluating students. Even when guidelines for constructing fair and systematic tests are followed, a couple of factors may enter into students' perception of the test items and cause errors in educational assessment and measurement. Item discrimination therefore assists the test developer in determining what is wrong with the individual items. It is therefore clear that distractor and discrimination analysis provide empirical data about how individual items and the whole tests are performing in real situations. As part of item analysis, for distractors to be plausible or function meaningfully, they should attract the uninformed. In this regard, the low achieving students must choose those distractors as compared to the high achieving students. Making inferences from the above analysis, all the ineffective distractors as well as the items that discriminate negatively needed to be replaced with a more effective ones to attract the uninformed and where necessary, the items should have been changed.

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APPENDIX A

CORE MATHEMATICS ACHIEVEMENT TEST- APRIL 2017

CANDIADTE'S NAME: …….....

Instructions:

Answer **ALL** questions on the question paper **(30 MARKS)** **TIME ALLOWED: 45MINS.**

Each question is followed by ***four*** options lettered A to D. Circle the letter of the correct or best answer to each question clearly. Do all rough work on this paper. The use of non-programmable, silent and cordless calculators is allowed.

Now answer the following questions.

1. Decrease 150 by 20%.
   A. 110
   B. 112
   C. 120
   D. 125
2. If $3(2x - 1) + 4 = 5(x + 4) + 2$, what is the value of x?
   A. 19
   B. 20
   C. 21
   D. 23
3. Find the truth set of $\frac{2}{3}(3y - 1) - (y + 2) = \frac{1}{3}$
   A. $\{y : y = 3\}$
   B. $\{y : y \neq 3\}$
   C. $\{y : y = -3\}$
   D. $\{y : y \neq -3\}$
4. Peprah is four times as old as Kojo. In ten years times, Peprah will be twice as old as Kojo. How old is Preprah?
   A. 5 years
   B. 10 years
   C. 20 years
   D. 25 years
5. Given that $\overrightarrow{OA} = \binom{3}{5}$ and $\overrightarrow{AB} = \binom{1}{4}$. If O is the origin, find $\overrightarrow{OB}$.
   A. $\binom{-2}{-1}$
   B. $\binom{-4}{-9}$
   C. $\binom{2}{1}$
   D. $\binom{4}{9}$
6. Find the value of $(x + y)$ if $x - 4y = 7$, and $4x + y = 11$.
   A. – 3
   B. – 2
   C. 2
   D. 3
7. $\frac{5}{6}$ of the number of pupils in a class is 4 greater than $\frac{3}{4}$ of the number in the class. What is the number of pupils in the class?
   A. 28
   B. 48
   C. 84
   D. More information is required.

8. Given that A (- 2, 4) and B (6, 2). If C is the midpoint of AB, find the position vector of C.
   A. $\begin{pmatrix} -3 \\ -2 \end{pmatrix}$
   B. $\begin{pmatrix} -2 \\ 3 \end{pmatrix}$
   C. $\begin{pmatrix} 2 \\ 3 \end{pmatrix}$
   D. $\begin{pmatrix} 3 \\ 2 \end{pmatrix}$
9. Simplify $(27 \times 3^{-2}) (8 \times 2^{-3})$
   A. – 3
   B. – 2
   C. 2
   D. 3
10. A tank contains 250 liters of water. If 95 liters is used, what is the percentage of the original is left?
   A. 60%
   B. 62%
   C. 66%
   D. 68%
11. Given that $y = \frac{2x-5}{3x+2}$, find y when $x = -4$
   A. – 1.3
   B. – 1.2
   C. 1.2
   D. 1.3
12. If $3x - 4 \leq 4 (x + 3)$, what is the value of x?
   A. $x \geq -16$
   B. $x \leq -16$
   C. $x \geq 16$
   D. $x \leq 16$
13. The sum of the ages of Kofi and Akosua is 29 years. Kofi is 3 years older than Akosua. How old is Akosua?
   A. 13 years
   B. 16 years
   C. 18 years
   D. Cannot be determined.
14. For what value of $\boldsymbol{x}$ is $3^{2x} = \frac{1}{81}$?
   A. – 3
   B. – 2
   C. 2
   D. 3
15. Find the truth set of $\frac{1}{2}x - \frac{1}{3}(x + 4) > 2x + \frac{3}{2}$
   A. $\left\{x : x < \frac{-17}{11}\right\}$
   B. $\left\{x : x > \frac{-17}{11}\right\}$
   C. $\left\{x : x \leq \frac{-17}{11}\right\}$
   D. $\left\{x : x \geq \frac{-17}{11}\right\}$
16. Which of the following is perpendicular to the vector $\begin{pmatrix} -1 \\ 3 \end{pmatrix}$?
   A. $\begin{pmatrix} 1 \\ 3 \end{pmatrix}$
   B. $\begin{pmatrix} 1 \\ -3 \end{pmatrix}$
   C. $\begin{pmatrix} -1 \\ -3 \end{pmatrix}$
   D. $\begin{pmatrix} -3 \\ -1 \end{pmatrix}$

17. Find the value of x if $2^{3x-1} = 128\sqrt{2}$.
    A. $\frac{-17}{6}$
    B. $\frac{-6}{17}$
    C. $\frac{6}{17}$
    D. $\frac{17}{6}$

Use the information below to answer questions 18, 19 and 20.

Muni spent $\frac{1}{5}$ of his monthly salary on food, $\frac{1}{2}$of the remaining on clothing and $\frac{1}{4}$ of what still remained on games. If he still had $ 900 left,

18. What is Muni's salary per month?
    A. $ 3,000,00
    B. $ 300, 000
    C. $ 3,000
    D. $ 300
19. How much did Muni spend on food?
    A. $ 600,000
    B. $ 60, 000
    C. $ 6,000
    D. $ 600
20. How much did Muni spend on clothing?
    A. $ 12
    B. $ 1,200
    C. $ 120,000
    D. $ 1,200,000
21. If $5^n = k$, find 5^{n+1}.
    A. $5k$
    B. 5^k
    C. $25k$
    D. 25^k
22. Which of the following is parallel to the vector$\binom{20}{8}$?
    A. $\binom{-4}{-10}$
    B. $\binom{-15}{-6}$
    C. $\binom{-2}{-5}$
    D. $\binom{-25}{10}$
23. If $2^{-n} = x$, find 2^n
    A. $\frac{-1}{x}$
    B. $-x$
    C. x
    D. $\frac{1}{x}$
24. Find the solution set of $3a - 2b = 8$ and $\frac{a}{2} + \frac{b}{2} = \frac{5}{4}$
    A. $\left\{a, b: a = -3,\ b = \frac{1}{2}\right\}$
    B. $\left\{a, b: a = \frac{1}{2},\ b = 3\right\}$
    C. $\left\{a, b: a = 3,\ b = \frac{1}{2}\right\}$
    D. $\{a, b: a = 3,\ b = \frac{-1}{2}\}$

Use the information below to answer questions 25, 26 and 27.

The coordinates of the vertices of a parallelogram QRST are $\mathrm{Q}(1,6), \mathrm{R}(2,2), \mathrm{S}(5,4)$ and $\mathrm{T}(x,y)$.

25. Find $\overrightarrow{QR}$ and $\overrightarrow{TS}$
    A. $\begin{pmatrix}1\\-4\end{pmatrix}$ and $\begin{pmatrix}5-x\\4-y\end{pmatrix}$
    B. $\begin{pmatrix}-4\\1\end{pmatrix}$ and $\begin{pmatrix}5-x\\4-y\end{pmatrix}$
    C. $\begin{pmatrix}-4\\-1\end{pmatrix}$ and $\begin{pmatrix}4-y\\5-x\end{pmatrix}$
    D. $\begin{pmatrix}-1\\-4\end{pmatrix}$ and $\begin{pmatrix}5+x\\4+y\end{pmatrix}$

26. What are the values of *x* and *y*?
    A. $x = -4$ and $y = -8$
    B. $x = -8$ and $y = -4$
    C. $x = 8$ and $y = 4$
    D. $x = 4$ and $y = 8$

27. What is the magnitude of $\overrightarrow{RS}$?
    A. $\sqrt{5}$ units
    B. $\sqrt{7}$ units
    C. $\sqrt{12}$ units
    D. $\sqrt{13}$ units

28. If $P = \begin{pmatrix}1&2&7\\3&2&5\end{pmatrix}$ and $Q = \begin{pmatrix}1&12&7\\3&y&0\end{pmatrix}$, find *y* if P + Q = $\begin{pmatrix}2&14&14\\6&-4&5\end{pmatrix}$
    A. – 6
    B. – 4
    C. 2
    D. 6

29. Given that, $-14 \leq 3x - 2 < 4$, which of the following set of values satisfy *x*?
    A. $x = \{-4,-3,-2,-1,0,1,2\}$
    B. $x = \{-3,-2,-1,0,1\}$
    C. $x = \{-2,-1,0,1,2\}$
    D. $x = \{-4,\ 2\}$

30. Given that $a = \begin{pmatrix}2\\1\end{pmatrix}, b = \begin{pmatrix}3\\4\end{pmatrix}$ and $c = \begin{pmatrix}-2\\5\end{pmatrix}$, evaluate $\boldsymbol{a + 2b - c}$
    A. $\begin{pmatrix}3\\0\end{pmatrix}$
    B. $\begin{pmatrix}6\\4\end{pmatrix}$
    C. $\begin{pmatrix}10\\4\end{pmatrix}$
    D. $\begin{pmatrix}10\\7\end{pmatrix}$