The Development of Local Wisdom-Based Physics Cognitive Ability Assessment Instrument for Senior High School Students

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Abstract

Today's young generation hardly recognizes the values of local wisdom around them. That is because of their lack of curiosity towards wisdom itself and the lack of means to learn it. Therefore, local wisdom needs to be integrated with learning particularly in high schools, especially in Klaten Regency, Indonesia. This study aims to develop an instrument of cognitive ability assessment based on local wisdom and find out its validity and reliability. The development of the assessment instrument refers to the instrument development model by Oriondo and Dallo-Antonio which is divided into 4 stages: designing the instrument, determining the validity of the instrument, testing the instrument, and determining the reliability of the instrument. The instrument was validated by educational evaluation experts, physicists, physics education experts, and practitioners. The content validity of the instrument was analyzed using the V-Aiken formula. The instrument consisted of 50 valid items based on expert judgment with an average coefficient of V-Aiken>0.78. Researchers tested 480 students and then analyzed the results of the trials using the Microsoft Excel, Quest, Parscale to determine their validity and reliability. The analysis showed that 50 items were fit with the Partial Credit Model (PCM). The reliability results showed 0.82.

Keywords: Local Wisdom, Assessment Instrument, Cognitive Ability, Validity, Reliability
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INTRODUCTION

Very tight global competition makes mastery of science and technology play an important role (Widodo, 2012). However, the demand for mastery of technology then shifts the cultural values that have long been preserved (Ningrum, 2018). Modern life has succeeded in changing the pattern of more individualistic community relationship and forgetting ancestral traditions as a result of the modern era industry (Usop, 2011). One of our challenges as citizens of Indonesian society with a variety of cultures is to maintain and preserve the existing cultural values (Widiastuti, 2013).

Learning values and morals are an inseparable component of daily life (Rusilowati *et al.*, 2012). Formal education in schools should be a link for students to learn how to live life according to the values and norms around (Widiastuti, 2013). It is important to develop the school culture that integrates scientific culture with local culture (Suparwoto, Youenyong *et al*., 2011, 2012). When local wisdom and science are combined, it can become new knowledge that can be an interesting learning solution (Pornpimon, Kassam, 2013, 2010). The purpose of the two sciences combined is, in addition to students getting to know the culture in local area, students can also more easily understand the material presented because it is in line with their own culture (Wahyuni, 2015).

Physics has an important role in understanding daily life phenomena (Baran, 2016). In fact, there are still some studies that show that the learning outcomes of students in science, especially physics, are not in line with the planned targets or can be said to be low (Aina and Akintunde, 2013). The low learning outcomes of physics is influenced by the view that some physical material is abstract and must use various types of equations or formulas (Adeyemo, 2012). Physics learning can be applied to be more interesting and relevant to everyday life (Putra, 2015). Learning material can be linked to the environment through local wisdom-based learning (Mungmachon, 2012).

An aim of physics in high school is that students have the ability to reason and understand physics concepts, so they can explain various natural phenomena and solve problems (Istiyono *et al*., 2014). This is reinforced by the government's recommendation in the Education Unit Level Curriculum. Aan assessment should be planned to measure knowledge and concepts, science skills, and high-level reasoning (Curriculum Center, 2007). Based on the survey result through interview of high

school physics teachers in the Special Region of Yogyakarta (DIY), it is obtained information that most schools use a one-level multiple choice test during the midterm and final semester exams (Istiyono *et al*., 2014). However, in a one-level multiple choice test, there are weaknesses that the test cannot explore students' ideas or opinions in depth. Students often answer the test by guessing without being based on reasons related to questions (Adodo, 2013).

From the various problems described earlier, various studies were then carried out related to the development of learning methods based on local wisdom. Some of the revelant studies include the following: 1) The Development of Outdoor Learning Models through Local Wisdom Based Simulation to Improve Cooperative Aspects and Cognitive Learning Outcomes (Dewi, 2017). The research aims to produce an outdoor learning model through simulation based on local wisdom in learning physics and finding out its effectiveness. 2) The Development of Local Wisdom-Based Science Learning Design to Develop Positive Characters in Primary Schools (Subali *et al*., 2015). The research aims to develop a science learning design based on local wisdom at the elementary school level. 3) The Development of Science Learning Media Based on Local Wisdom to Enhance Students' Critical Thinking Ability (Wahyuni, 2015). The research aims to develop science learning media including textbooks, student worksheets, syllabus, and lesson plans based on local wisdom to improve the critical thinking skills of junior high school students.

Most of these revelant studies developed the learning model only. Therefore, this research tries to create something new, namely developing an instrument of cognitive ability assessment in high school physics subject based on local wisdom. The quality of learning and the quality of assessment are interconnected (Golf, 2015). A good learning system will produce good judgment as well (Bevel, 2010). Therefore, the quality of learning greatly influences the result of the assessment (Taroreh *et al.,* 2012). Assessment is part of the learning process that can not be separated (Jiraro, 2014). The success of a learning process can be seen from the assessment of student learning outcomes, especially in aspects of knowledge or cognitive aspects (Arends & Kilcher, 2010). Student learning outcomes are always used to measure the quality of a school (Taurina, 2015). Schools become famous when students' learning outcomes are high (Powel & Davies, Thoha & Wulandari, 2011, 2016).

Assessment is one important part of the learning process that must be controlled by teachers and educators (Shepardson, 2011). Teachers in the learning process can determine learning achievement and determine how to assess it (Khairunnisa *et al*., 2017).

This research focuses on developing a valid and reliable cognitive ability assessment instrument. This instrument developed in the form of closed-choice multiple choice tests or often called multilevel multiple choice. The first part of the test is the question with the choice of answers, the second part is the choice of reasons from the answers already chosen (Chandrasegaran, 2007). The advantage of this two-tier multiple-choice test is that students can choose reasons to consider the answers they have chosen (Duncan & Johnstone, 1973). In addition, this test is easier in correcting the answers and reasons of students (Suparno, 2005). Tamir (1989) revealed that two-tier multiple-choice test is a sensitive and effective way to assess learning that is meaningful for students. It is often used to identify students' misconceptions. This test is also easy to do and does not take much time. Tamir (1971) also revealed that this two-tier multiple-choice test gives students the opportunity to present ideas or provide alternative choices of concepts they understand. In addition, they can justify the answers they choose by giving reasons.

The development of this instrument is based on Item Response Theory (IRT). This instrument was developed using PCM (Partial Credit Model). PCM is an extension of the Rasch 1-PL Model (Abedalaziz, 2013). Initially, the Rasch Model was used to analyze the dichotomous score data (two categories), which is true false with a score of 1-0, then developed by Masters into the Rasch Model politomus (a score higher than the two categories) now known as PCM. PCM was developed to analyze test items requiring many steps in the completion process (Masters, 1999). PCM is suitable to use in physics problems that require a stage in identifying problems to produce solutions to the problems (Istiyono *et al.*, 2014).

This study aims to develop an instrument to assess the cognitive abilities of high school students based on local wisdom and to find out the characteristics of the assessment instrument. The assessment instrument was used to assess the cognitive abilities of high school students on learning outcomes in physics subject particularly in cognitive ability (Dahmann, 2017). The local wisdom used was traditional seesaw game, bamboo spinning top, and

Plaosan temple building in Klaten Regency, Central Java. Cognitive ability assessment instrument developed in form of close-reasoned multiple choice questions. In addition to developing the assessment instruments of cognitive abilities, students are also expected to be able to recognize and re-understand the values of local wisdom around (Saputra, 2013).

METHOD

This research is a development research aiming to construct an assessment instrument of cognitive abilities based on local wisdom. The research instrument development model refers to the model developed by Oriondo and Antonio (Yaghmale, 2003). It consists of planning the instrument, determining the validity of the instrument, testing the instrument, and determining the reliability of the instrument (Cohen *et al.*, 2011).

Designing the Assessment Instrument

The purpose of this step is to produce an instrument design. The intended instrument is an assessment instrument to measure the cognitive abilities of class XI students in Physics subject on the balance of rigid body and rotational dynamics learning material. The planning step of the test consists of several steps, namely determining the purpose of the test, compiling the blueprint test, determining the form of the test, writing the test script, and revising the test script (Istiyono *et al.*, 2014).

The first step is to determine the purpose of the test instrument adjusted to the syllabus of the physics material used. The second step is determining the test lattice. The test grid should refer to the syllabus with regard to the basic competencies and indicators to be achieved. Next is to determine the shape of the instrument. This study used an assessment instrument in form of closed-minded multiple choice. The next step is writing the test script then corrected by an expert. The final step is to revise the test script based on corrections from the expert.

Determining the Instrument Validity

This step was carried out to determine the validity of the contents of the instrument. Validity is the determination of an instrument in measuring what is measured (Subali, 2011). Content validity score is obtained based on expert judgment. For this purpose, a number of experts were appointed, both educational evaluators, materials, and practitioners. The minimum number of recommended experts is five so that they have sufficient control over the differences in judgment. However, if the number of experts is more than ten or even more, the experts make the possibility of

agreement decreasing (Masters, Oriondo & Antonio, 1999, 1985). The assessment obtained from experts is in form of suggestions, input, or criticism and quantitative values with range of scores from 1 to 4. The quantitative scores were analyzed to determine the validity of the contents using a formula developed by Aiken. The formula for calculating the V-Aiken index is as follows (Azwar, 2012).

$$V = \frac{\sum s}{(n(c-1))} \quad (1)$$

From the equation (1) V representing the Aiken's V index V, $\sum s$ is the number s of n rater with $s = r - l_0$, r is the score given by the evaluator, l_0 is the lowest validity rating score, and c is the highest validity assessment score. The minimum V-Aiken index to be said to be valid must be adjusted to the table of validity coefficients (Arends & Kilcher, 2010). For example: if the number of rater is 6 people and 4 assessment categories, the minimum Aiken's V index that must be obtained is 0.78.

After the content validity by experts, then item validity was presented after testing using Pearson Product Moment Correlation. The calculation was done by correlating the item score with the total item score. From the results of the calculation of correlation, a correlation coefficient was obtained which was used to measure the level of validity of an item and to determine whether an item is suitable to use or not. In determining whether an item is appropriate or not, a significance coefficient correlation test is usually presented at the 0.05 significance level. This means that an item is considered valid if it has a significant correlation to the total score. When conducting a direct assessment of the correlation coefficient, the minimum correlation value of 0.30 can be used. According to Azwar (2012) if all items reaching a correlation coefficient of at least 0.30, the distinguishing power is considered satisfactory. The calculation results are compared with r in the criticism table. If r count> r table, the item is declared valid. In other words, validity is considered good if r count> 0.3 (Azwar, 2012). However, Azwar said that if the number of items is not sufficient we can lower the criteria limit by 0.30 to 0.25, but lowering the criteria limit to below 0.20 is not recommended.

Testing the Instrument

After doing revision based on the suggestions and input from the experts and determining the validity of the content, the valid test instruments would be tested on a number of students from high, medium and low quality schools. The researcher determine the high, medium, and low of a school based on the national final examination results.

The test instrument was tested on 480 students from 7 schools in Klaten Regency, Central Java.

Determining the Intstrument Reliability.

The instrument reliability can be tested by several reliability tests. The development of this instrument used a reliability test by the Quest and Parscale program and also used the Cronbach Alpha technique (Nitko, 2011).

Test reliability in IRT was tested using Quest software. The estimated reliability of the item according to the IRT is based on the item and is called the item spatial index (DeMars, 2010). If the reliability score of the item is estimated at 1.00, the sample reliability is very high. The higher the estimated item sparation index, the more precisely the overall items analyzed according to the model used (Adam & Khoo, 1996), as well as the reliability of the test with a scoring politomus based on the Cronbach Alpha coefficient.

Data/Material

The local wisdom used in this study is the traditional seesaw game, bamboo spinning top game, and the building of Plaosan Lor Temple.

Plaosan Lor Temple

Plaosan Temple is the name of a temple complex located in Dukuh Plaosan, Bugisan Village, Prambanan District, Klaten Regency, Central Java Province, Indonesia. The temple is located one kilometer northeast of Sewu Temple or Prambanan Temple. The Plaosan Lor Temple complex has two main buildings located in the north and the south (Febrina, 2010). Picture 1 below is the main building of Plaosan Lor Temple:

Picture 1. The Main Building of Plaosan Lor Temple

The two main temples are surrounded by 116 ancillary stupas and as many as 50 ancillary temples, as well as artificial trenches. In each main temple there are six statues. Picture 2 below is one of the statues in Plaosan Lor Temple:

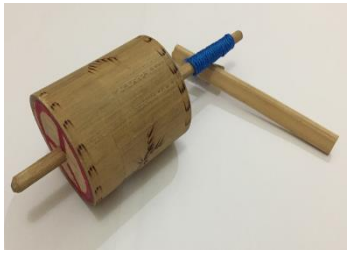
Picture 2. Dwarapala Statue in Plaosan Lor Temple

The local wisdom of the temple building was integrated in the physics subject in the equilibrium section of the rigid sub-section. The concept of center of gravity on the temple building is the support of the rocks on it so that it becomes a sturdy building and does not

easily collapse during an earthquake. This concept was integrated later into the students' cognitive ability assessment instrument.

Bamboo Spinning Top

Spinning Top or often called Gangsing is a game that can rotate on one axis and can be continuous. It is the oldest traditional toy. It is recognized by almost all Indonesian people. Aside from being a toy for children and adults, top is also used for gambling and fortune telling. Gasing is one of the traditional games of the archipelago, although the history of its spread is not known with certainty (Wikipedia.org).



Picture 3. Bamboo Spinning Top

The way to play the bamboo top is to use a rope and a bamboo blade as a rope grip. The rope is wrapped around a bamboo rod located in the middle of the top and then the top is pulled off while pulling the rope around it. The topwill be detached from the loop of rope and thrown in a circular motion to the ground. If the method is right, the top will spin on one axis and rest on one point of equilibrium (Maria, 2014). This case will later be used as a simulator when measuring inertia on a tube. Local wisdom in the form of bamboo top in this study will discuss the material of rotational dynamics.

Seesaw Game

Seesaw is a game that has a long and narrow board pivoting in the middle, so that if one end moves up, the other end moves down. The seesaw will be balanced if it has the same weight on both sides and the same distance from the shaft. The concept of the seesaw game is related to the concepts of physics of torque and balance.

Picture 4. Seesaw Game (jihanpratiwi95.wordpress.com).

These three local wisdoms were then integrated into the material of rigid body equilibrium and rotational dynamics. Examples of items that have been made by researchers can be seen in Table 3.

RESULTS AND DISCUSSION

This results and discussion section presents the results of the study as well as the supporting data.

The validity of Content by Experts

The specifications of the test and the preparation of items compiled are based on the Basic Competencies used in the Curriculum 2013 in Indonesia.

The number of items in this valuation instrument is 50 items in form of close-reasoned multiple choice. One item consists of 5 multiple choices and 5 reasons. After compiling blueprint, indicators, and 50 item items, the next step is the validation phase of the assessment instrument by the experts of educational evaluation, physics, physics education, and practitioners. The criteria for each item/no cognitive ability assessment instrument are the Table 1:

Table 1. The Validation Sheet for Each Item on the Cognitive Ability Assessment Instrument

No.	Rated Aspect	Validity	
		Yes	**No**
Material			
1.	The items are developed according to indicators of competency achievement.		
2.	The material/substance asked in accordance with the level of education.		
3.	The choice of answers is logical and homogeneous.		
4.	There is only one answer key.		
Structure			
5.	The subject matter is clearly formulated.		
6.	The instructions for questions are clearly formulated.		
7.	The items do not depend on the previous questions.		
8.	Using question words or commands that require answers.		
9.	The length of the answer formulation is relatively the same.		
10.	The formulation of questions and answers are necessary statements.		
11.	The subject matter does not provide key answer clues.		
12.	Be consistent in using terms, symbols, and units.		
13.	Tables, graphs, diagrams, cases, or other part are meaningful (clear or presenting information related to the stated problem).		
14.	The questions and rubrics and/or scoring guidelines are formulated correctly.		
15.	The answer choices in numbers and times are arranged in chronological order.		
Language			
16.	The sentence formulation uses communicative language and is easy to understand.		
17.	The sentence uses good and appropriate language.		
18.	Do not use the local language.		

The number of rater who assessed the assessment instruments was 3 expert lecturers and 3 practitioners or physics subject teachers. The results of content validation by experts were determined by calculating the V-Aiken coefficient. The coefficient applies to each item of cognitive ability assessment instrument. V-Aiken criteria that must be met if the number of rater is 6 people and rating scale 4 is 0.78 (Aiken, 1985). The

recapitulation results of the assessment of the experts and practitioners that the V-aiken coefficient scores have been calculated can be seen in Table 2.

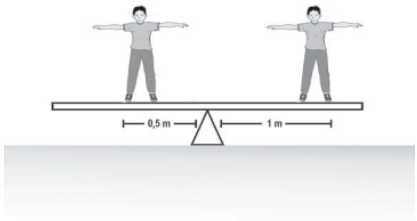
Table 2. The Recapitulation of Results of Content Validation by Experts

Item	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
V Aiken	0,94	1,00	0,72	0,56	1,00	1,00	0,67	1,00	1,00	1,00
Item	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
V Aiken	1,00	0,83	0,89	1,00	0,94	1,00	1,00	1,00	1,00	1,00
Item	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
V Aiken	1,00	1,00	0,67	1,00	1,00	1,00	1,00	1,00	0,67	1,00
Item	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
V Aiken	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,61	0,94	1,00
Item	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
V Aiken	1,00	0,72	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,61

Based on Table 2. above, there were some coefficients that are still <0.78, it showed by the red column, there are 8 invalid items and 42 valid items. The invalid items can be revised until they are valid or discarded. Based on table 2 also, the researcher revised several items that are invalid so that all 50 items are valid based on expert validation. These 50 valid items were tested on 480 grade XI science students in several high schools in Klaten Regency, Central Java. Following are 50 items tested on 480 students to determine validity and reliability.

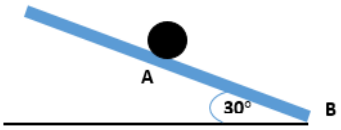
Table 3. The Valid items Validated by The Experts.

Question Indicator	No	Question Item
Explain the understanding of torque.	1	The magnitude that can cause a point of a particle to rotate is called ... A. Angular momentum B. Momentum C. Inertia D. Angular acceleration E. Torque Reason: A. Angular momentum occurs in rotating objects. B. Torque gives rise to angular acceleration so that rotational motion occurs. C. Torque is the product of the moment of inertia with angular velocity. D. The moment of inertia of an object depends on the location of the rotary axis or shaft that causes the object to rotate. E. The angular acceleration occurs in forces that move in a circle.
Analyzing figures about the concept of	2	A blacksmith who fixes the Plaosan Temple fence needs a bolt turning tool. Based on the following figure, the location of the

torque.	hand which is easier to do to turn the bolt is ...  (a) (b) (c) A. Figure (a) is easier to do to turn a bolt B. Figure (b) is easier to do to turn the bolt C. Figure (c) is easier to do to turn the bolt D. Figure (c) and (a) are easier to do to turn the bolt E. Figure (a) and (b) are easier to do to turn the bolt Reason: A. Figure (a) has the shortest arm of all three figures. B. Figure (c) has the longest arm style among the three figures. C. Figure (b) has the smallest force among the three figures. D. The size of the arm force does not affect the amount of force required. E. E. The force on all images is zero.
3	One end of a seesaw is mounted by a child whose mass is 15 kg. The other end is ridden by a child whose mass is 20 kg. The distance of each child from the fulcrum is 1 m and 0.5 m. If the magnitude of the acceleration of gravity is 9.8 m/s^2, then the total moment of force is ...  A. 49 Nm B. 98 Nm C. 147 Nm D. 245 Nm E. 258 Nm Reason: A. The direction of the two children's style moments is in the same direction. B. The moment of force of the two children is the same. C. The direction of the style moment of the two children is different. D. The moment of inertia of the two children is the same. E. E. The amount of inertia between the two children is different.

4 A child playing marbles with a mass of 10 grams. He rolls the marble on the rough sloping board like the following picture. The marble is released from A without initial speed. If the radius of a marble is 0.5 cm, the moment of force acting on the marble is ...

A. $2{,}5 \times 10^{-7}$Nm
B. 25×10^{-5}Nm
C. 5×10^{-4}Nm
D. 1 Nm
E. 20 Nm

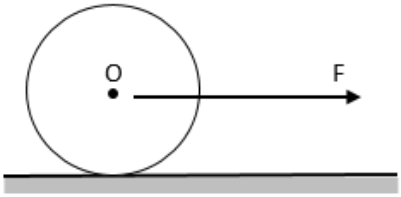


Reason:

A. The gravitational effort only transforms into frictional effort.
B. The kinetic energy arising is translational kinetic energy because when rolling, marbles move.
C. The more oblique plane of angular acceleration is greater so that the moment of force produced is greater.
D. The kinetic energy arising is rotational kinetic energy because the frictional force can cause a moment of force.
E. E. The rough field does not affect the magnitude of the force moment so that the moment is ignored.

5 An Andong wheel rolls perfectly on a flat, rough plane. The wheel mass is 5 kg and the wheel radius is 50 cm. The wheel is pulled by a horse with a force F = 5 N so that it moves with constant acceleration. The great moment of force acting on the wheels is ...

A. 0.025 Nm.
B. 0.25 Nm.
C. 0.20 Nm.
D. 1.25 Nm.
E. 2.5 Nm.



Reason:

A. The torque of the rotating wheel is $\tau = r \times F$
B. The torque of the rotating wheel is $I = \frac{2}{5}(m \cdot r^2)$
C. The torque of the rotating wheel is $I = \frac{1}{2}(m \cdot r^2)$
D. The torque of the rotating wheel *is* $I = m \cdot r^2$
E. The torque of the rotating wheel is $\tau = r \times F$

6 A child plays a cylindrical top that has a 4 cm radius. If the child's force in pulling a top is 1 N, what is the torque on the top played ...

A. 0.04 Nm
B. 0.4 Nm
C. 0.8 Nm
D. 1.6 Nm
E. 4 Nm

Reason:

A. The torque of the spinning top is $\tau = r \times F = 4$ m $\times$ 1 N
B. The torque of the spinning top is $\tau = r \times F = 0.04$ m $\times$ 1 N
C. The torque of the spinning top is $I = m \cdot r^2 = 0.1$ N $\cdot 4^2$

		m D. The torque of the spinning top is $I = \frac{1}{2}(m \cdot r^2) = \frac{1}{2}(0{,}1\ \text{N} \cdot 4^2\ \text{m}$ E. The torque of the spinning top is $I = m \cdot r^2 = 4\ \text{m} \cdot (0{,}1)^2\ \text{m}$.
Determining the arm force using the torque equation	7	It is known that the torque of an object is 50 Nm, and the force used is 5 N. If the force is perpendicular to the arm, determine how much the force moment of the force moment ... A. 0.032 m B. 0.1 m C. 2.5 m D. 3.2 m E. 10 m Reason: A. The arm force on the object is $= \frac{\tau}{F} = \frac{50\ \text{Nm}}{5\ \text{N}} r = 10$ cm. B. The arm force on the object is $r = \sqrt{\frac{l}{m}} = \sqrt{\frac{50\ \text{kgm}^2}{5\text{kg}}} = \sqrt{10\ \text{m}^2}$ = 3.2 cm. C. The arm force on the object $r = \frac{\tau}{F} = \frac{50\ \text{Nm}}{5\ \text{N}}$ r = 10 m. D. The arm force on the object is $r = \sqrt{\frac{l}{m}} = \sqrt{\frac{50\ \text{kgm}^2}{5\text{kg}}} = \sqrt{10\ \text{m}^2}$ = 3.2 m. E. The arm force on the object is $r = \tau\ x\ F$ = 250 m = 2.5 cm.
Mentioning the factors that influence the inertia	8	There followings are 4 physical quantities related to factors of the rotational motion: 1) The Angular velocity 2) The location of the pivot axis 3) The shape of objects 4) The mass of objects Factors that influence the magnitude of inertia are ... A. (1) and (4) B. (1), (2), and (3) C. (1), (3), and (4) D. (2), (3), and (4) E. (2) and (4) Reason: A. The inertia is a multiplication result of a mass of particle and the square of the distance of the particle to its axis, and the inertia for each object is different. B. The inertia is a multiplication result of the particle and the square of the distance of the particle to its axis, and the inertia for each object is the same. C. The inertia is a multiplication result of an arm force and force, and the inertia for each object form is different. D. The inertia is a multiplication result of an arm force and force, and the inertia for each object is the same. E. The inertia depends only on the location of the axis rotation and the mass of the object.
Determining the comparison of inertia in traditional games	9	A child has two cylindrical tops. Each top has a different radius. Top A has a radius greater than top B. If the top is played, the inertia is ...

A. The inertia of top A is equal to the inertia of top B
B. The inertia of top A is smaller than the inertia of top B
C. The inertia of top A is greater than the inertia of top B
D. The inertia from top A is far different from the inertia of top B
E. Both gasing have no inertia when they spin

Reason:
A. The radius does not affect the inertia.
B. The radius is inversely proportional to the inertia
C. The radius is directly proportional to the inertia.
D. The radius is inversely proportional to the inertia.
E. The inertia is zero.

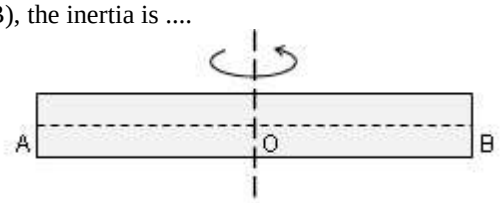
	10	A solid cylinder has a radius of 8 cm and a mass of 2 kg, while the solid ball has a radius of 5 cm and a mass of 4 kg. If the two objects rotate with the axis through its center, the ratio of the moment of inertia of I_a and I_b is …. A. $Ia: Ib$ = 16: 5 B. $Ia: Ib$ = 8 : 5 C. $Ia: Ib$ = 5 : 8 D. $Ia: Ib$ = 4 : 1 E. $Ia: Ib$ = 2 : 1 Reason: A. The equation of inertia of the solid cylinder is $I = \frac{1}{2}mr^2$ and the equation of inertia of the solid ball is $I = \frac{2}{5}mr^2$. B. The equation of inertia of the solid cylinder is $I = \frac{1}{2}mr^2$ and the equation of inertia of the solid ball is $I = mr^2$. C. The equation of inertia of the solid cylinder is $I = \frac{1}{2}mr^2$ and the equation of inertia of the solid ball is $I = \frac{2}{3}mr^2$. D. The equation of inertia of the solid cylinder is $I = \frac{2}{5}mr^2$ and the equation of inertia of the solid ball is $I = mr^2$. E. The equation of inertia of the solid cylinder is $I = \frac{2}{5}mr^2$ and the equation of inertia of the solid ball is $I = \frac{1}{2}mr^2$.
Determining the inertia of objects in traditional games	11	At a particular location of Plaosan Temple, there is a homogeneous stick of 1.5 kg in mass and 10 m in length. The stick is rotated with the center of rotation at one end. The inertia of the stick is …. A. 10 kgm^2 B. 20 kgm^2 C. 30 kgm^2 D. 40 kgm^2 E. 50 kgm^2 Reason: A. The coefficient of the inertia of the homogeneous stick with the shaft end is 1. B. The coefficient of the inertia of the homogeneous stick with the shaft end is $\frac{1}{3}$. C. The coefficient of the inertia of the homogeneous stick

with the shaft end is $\frac{2}{3}$.

D. The coefficient of the inertia of the homogeneous stick with the shaft end is $\frac{2}{5}$.

E. The coefficient of the inertia of the homogeneous stick with the shaft end is $\frac{1}{2}$.

12 AB rod of mass 2 kg rotated through point A turns out to be the inertia of 4 kgm2. When rotated through the center point O (AO = OB), the inertia is ....



A. 24 kgm^2
B. 16 kgm^2
C. 6 kgm^2
D. 1 kgm^2
E. 0.7 kgm^2

Reason:

A. The the inertia when rotated through point A ($I_A = \frac{1}{3}mL^2$) and when rotated through point O ($I_o = \frac{1}{12}mL^2$).

B. The inertia when rotated through point A A ($I_A = \frac{1}{12}mL^2$) and when rotated through point O ($I_3 = \frac{1}{3}mL^2$).

C. The inertia when rotated through point A ($I_A = \frac{1}{2}mL^2$) and when rotated through point O ($I_o = \frac{1}{2}mL^2$).

D. The inertia when rotated through point A ($I_A = \frac{1}{12}mL^2$) and when rotated through point O ($I_o = \frac{1}{2}mL^2$).

E. The inertia when rotated through point A ($I_A = \frac{1}{3}mr^2$) and when rotated through point O ($I_o = \frac{1}{2}mr^2$).

13 A top has a solid cylindrical shape and has a radius of 2 cm and a mass of 150 gr. The inertia produced by the top is …

A. 2×10^{-5} kg m^2
B. 3×10^{-5} kg m^2
C. 6×10^{-5} kg m^2
D. 2×10^{-1} kg m^2
E. 3×10^{-1} kg m^2

Reason:

A. The inertia of the spinning top is $I = \frac{1}{3}mr^2$.

B. The inertia of the spinning top is $I = 2mr^2$.

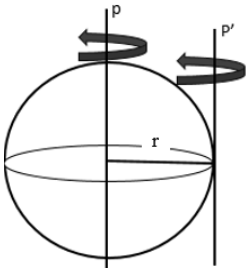
C. The inertia of the spinning top is $I = \frac{1}{2}m \cdot r^2$.

D. The inertia of the spinning top is $I = m \cdot r^2$.

E. The inertia of the spinning top is $I = \frac{1}{3}mr^2$.

14 The inertia of the solid ball as it rotates with the rotary axis passing through the center of the ball is $I = \frac{2}{5}mr^2$. The magnitude of the inertia when the shaft (rotary axis) shifts as far as r to the edge of the sphere is...

A. $\frac{11}{5}mr^2$
B. $\frac{7}{5}mr^2$
C. $\frac{16}{15}mr^2$
D. $\frac{4}{5}mr^2$
E. $\frac{4,5}{10}mr^2$

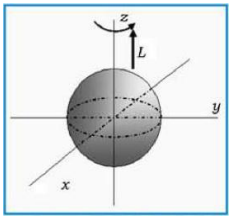


Reason :

A. The inertia when the axis is on the edge of the ball can be determined by the equation $I' = \frac{2}{5}mr^2 + mr^2$.
B. The inertia when the axis is on the edge of the ball can be determined by the equation of $I' = \frac{2}{5}mr^2 + \frac{1}{3}mr^2$.
C. The inertia when the axis is on the edge of the ball can be determined by the equation of $I' \frac{2}{5}mr^2 + \frac{2}{3}mr^2$.
D. The inertia when the axis is on the edge of the ball can be determined by the equation of $I' = \frac{2}{5}mr^2 + \frac{2}{5}mr^2$.
E. The inertia when the axis is on the edge of the ball can be determined by the equation of $I' = \frac{2}{5}mr^2 + \frac{1}{2}mr^2$.

15 In Prambanan Temple, there are toys sold in form solid balls. A homogeneous solid ball with a diameter of 0.6 m and mass of 15 kg rotates to the z axis through its center of mass. The angular momentum when the angular velocity of 3 $\frac{\text{rad}}{\text{s}}$ is ….

A. 0.43 $\frac{\text{kgm}^2}{\text{s}}$
B. 0.54 $\frac{\text{kgm}^2}{\text{s}}$
C. 0.90 $\frac{\text{kgm}^2}{\text{s}}$
D. 1.35 $\frac{\text{kgm}^2}{\text{s}}$
E. 1.62 $\frac{\text{kgm}^2}{\text{s}}$



Reason:

A. The momentum of the solid ball angle is $= l\,\omega^2$.
B. The momentum of the solid ball angle is $I = \frac{2}{5}mr^2$.
C. The momentum of the solid ball angle is $= l\,\omega$.
D. The momentum of the solid ball angle is $I = \frac{2}{3}mr^2$.
E. The momentum of the solid ball angle is $I = mr^2$.

16 A rope is wrapped around a bamboo top with a mass of 0.8 kg and radius in 2 cm and 4 cm outside. We consider the bamboo top as a hollow cylinder. If the torque acting on a top is 2.5 Nm, the angular acceleration of the bamboo top is.... ($I = m(R_1^2 + R_2^2)$)

A. 375 $\frac{\text{rad}}{\text{s}^2}$
B. 650 $\frac{\text{rad}}{\text{s}^2}$
C. 781.25 $\frac{\text{rad}}{\text{s}^2}$
D. 1562.5 $\frac{\text{rad}}{\text{s}^2}$
E. 1953.125 $\frac{\text{rad}}{\text{s}^2}$

Reason :

A. The angular acceleration depends on the mass, the radius, and the torque.
B. Angular acceleration depends on the mass, the angular momentum, and the torque.
C. The angular acceleration depends on the inertia, the angular momentum, and the angular velocity.
D. The angular acceleration depends on the radius, the angular momentum, and the torque.
E. The angular acceleration depends on the inertia and the angular acceleration.

17 There is a homogeneous disc-shaped carriage wheel with a radius of 50 cm and a mass of 200 kg. If the torque acting on the wheel is 250 Nm, the angular acceleration of the wheel is ….

A. $2.5\ \frac{\text{rad}}{\text{s}^2}$
B. $5\ \frac{\text{rad}}{\text{s}^2}$
C. $7.6\ \frac{\text{rad}}{\text{s}^2}$
D. $10\ \frac{\text{rad}}{\text{s}^2}$
E. $12.25\ \frac{\text{rad}}{\text{s}^2}$

Reason:

A. The angular acceleration of the wheel is influenced by the inertia with the equation of $I = \frac{2}{3}mr^2$.
B. The angular acceleration of the wheel is influenced by the inertia with the equation of $I = \frac{2}{5}mr^2$.
C. The angular acceleration of the wheel is influenced by the inertia with the equation of $I = \frac{1}{2}mr^2$.
D. The angular acceleration of the wheel is influenced by the inertia with the equation of $I = \frac{1}{3}mr^2$.
E. The angular acceleration of the wheel is influenced by the inertia with the equation of $I = mr^2$.

18 A child visiting Plaosan Lor Temple finds an object in the temple courtyard. The child plays the object by kicking and the object rotates with the inertia of 2.5 x 10-3 kg m2 and an initial angular velocity of 5 $\frac{\text{rad}}{\text{s}}$. In order the object to stop within 2.5 seconds, the torque that must be worked on is …

A. 4.0 x 10^{-3} Nm
B. 5.0 x 10^{-3} Nm
C. 6.0 x 10^{-3} Nm
D. 7.0 x 10^{-3} Nm
E. 8.0 x 10^{-3} Nm

Reason:

A. The angular acceleration does not affect the large moment of the torque.
B. The angular velocity does not affect the large moment of the torque.
C. The density of objects influences the torque.
D. The angular acceleration affects the large moment of the torque.
E. The volume of an object influences the torque.

Calculating the angular momentum of an object	19	A bamboo spinning top with a mass of 0.5 kg and radius of 2 cm inside and 4 cm outside is played by a child. It rotates against its axis at an angular velocity of 4 $\frac{\text{rad}}{s}$. If we consider it as a hollow cylinder, the angular momentum of the bamboo spinning top on the axis of rotation is … A. $2 \times 10^{-3} \frac{\text{kgm}^2}{s}$ B. $4 \times 10^{-3} \frac{\text{kgm}^2}{s}$ C. $8 \times 10^{-4} \frac{\text{kgm}^2}{s}$ D. $27 \times 10^{-4} \frac{\text{kgm}^2}{s}$ E. $29 \times 10^{-4} \frac{\text{kgm}^2}{s}$ Reason: A. The angular edge magnitude of the bamboo top is $L = \frac{1}{2} m R_1^2$. B. The angular edge magnitude of the bamboo top $L = \frac{2}{3} m(R_1^2 + R_2^2)\, \omega$. C. The angular edge magnitude of the bamboo top is $L = \frac{1}{2} m(R_1^2 + R_2^2)\, \omega$. D. of the bamboo top is $L = \frac{2}{5}\, m\, (R_1 + R_2)^2 \omega$. E. The angular edge magnitude of the bamboo top is $L = m(R_1^2 + R_2^2)\, \omega$.
Identifying the problem of angular momentum on an object	20	A student is sitting on a chair that can be rotated. First he spread his arms and turned his chair. Then, still spinning, he stretches his arms down. As a result, the rotation speed he is experiencing now is ... A. Getting faster, because the inertia becomes smaller B. Getting faster, because the inertia becomes large C. Getting slower, because the inertia becomes large D. Getting slower, because the inertia becomes smaller E. Do not experience any changes. Reason: A. The speed is directly proportional to the inertia. B. The inertia affects the speed. C. The speed is zero. D. The speed is inversely proportional to the inertia. E. The inertia has no effect on the speed.
Determining the angular velocity and inertia using the equation of the law of conservation of momentum	21	A ballet dancer spins with arms outstretching at an angular velocity (ω) of 1.5 round per second on a slippery floor with a moment of inertia (I) of 6 kgm2. Then, his hands cross on his chest. The possible pair of ω and I in the final condition is …

	ω (round per second)	I (kg m^2)
A.	1	9
B.	1.5	6
C.	2	4.5
D.	3	4.5
E.	5	3.0

Explanationn :

A. Based on the law of conservation of angular momentum (constant angular momentum), when the dancer crosses

her arms to her chest then $\omega_2 > \omega_1$.

B. Based on the law of conservation of angular momentum (constant angular momentum), when the dancer crosses the arms to the chest then $\omega_2 < \omega_1$.

C. Based on the law of conservation of angular momentum (constant angular momentum), when the dancer crosses the arms to the arms then $I_2 = I_1$.

D. Based on the law of conservation of angular momentum (constant angular momentum), when the dancer crosses the arms to the arms then $I_2 > I_1$.

E. Based on the law of conservation of angular momentum (constant angular momentum), when the dancer crosses the arms to the chest then $\omega_2 = \omega_1$.

22 An Black Mask dancer performs a circular motion with a frequency of 2 rounds per second and the inertia is 10 kgm2 when her arms are stretched. Then she folds his arms in front of her chest so she can do 4 rounds per second. The inertia in that state is ….

A. 2 kgm^2
B. 4 kgm^2
C. 5 kgm^2
D. 10 kgm^2
E. 15 kgm^2

Reason :

A. Based on the law of conservation of angular momentum (constant angular momentum), when a dancer crosses her arms to her chest then $\omega_2 < \omega_1$.

B. Based on the law of conservation of angular momentum (constant angular momentum), when the dancer crosses her arm to arm then $I_2 = I_1$

C. Based on the law of conservation of angular momentum (constant angular momentum), when the dancer crosses her arm to arm then $I_2 > I_1$

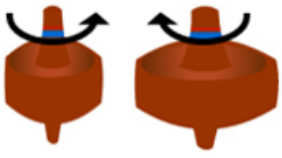
D. Based on the law of conservation of angular momentum (constant angular momentum), when a dancer crosses her arms to his chest then $\omega_2 = \omega_1$.

E. Based on the law of conservation of angular momentum (constant angular momentum), when the dancer crosses her arm to arm then $I_2 < I_1$.

Comparing the relationship between the interactions of one top with another top (different radius).

23 Two spinning tops have the same thickness and are made from the same material, but have different radius r_1 and r_2. The two tops are the given an angular velocity of each $\boldsymbol{\omega}_1$ and $\boldsymbol{\omega}_2$, and are brought into contact with the edges. After the spinning top interacts through friction, it is found that the two tops stop. The following relationships are correct …

A. $\omega_1 r_1^4 = \omega r_2^4$
B. $\omega_1 r_1^3 = \omega_2 r_2^3$
C. $\omega_1 r_1^2 = \omega_2 r_2^4$
D. $\omega_1 r_1^4 = \omega_2 r_2^2$
E. $\omega_1 r_1 = \omega_2 r_2$



Gasing 1 Gasing 2

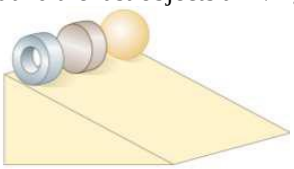
Reason:

A. The greater the radius of the top, the greater the angular momentum

B. The greater the angle velocity of the top, the greater the

		angular momentum C. The angular momentum of the system is permanent or unchanging. D. The angular momentum of the system changes irregularly E. The greater the moment of inertia top, the greater the angular momentum
Calculating the rotational kinetic energy of an object	24	A solid cylinder whose mass is 2 kg moves in a circle with an angular velocity of 20 π rad/s. If the solid cylinder has a radius of 20 cm, the kinetic energy of the solid cylinder rotation is ... A. 16 π^2 J B. 10.7 π^2 J C. 8 π^2 J D. 6.4 π^2 J E. 5.3 π^2 J Reason : A. The kinetic energy of the solid cylindrical rotation is $E_k = \frac{1}{2} I\omega^2 = \frac{1}{2} mR^2\omega^2$ B. The kinetic energy of the solid cylindrical rotation is $E_k = \frac{1}{2} I\omega^2 = \frac{1}{2}\frac{1}{2} mR^2\omega^2$ C. The kinetic energy of the solid cylinder rotation is $E_k = \frac{1}{2} I\boldsymbol{\omega}^2 = \frac{1}{2}\frac{2}{3} mR^2\boldsymbol{\omega}^2$ D. The kinetic energy of the solid cylindrical rotation is $E_k = \frac{1}{2} I\boldsymbol{\omega}^2 = \frac{1}{2}\frac{2}{5} mR^2\boldsymbol{\omega}^2$ E. The kinetic energy of the solid cylinder rotation is $E_k = \frac{1}{2} I\boldsymbol{\omega}^2 = \frac{1}{2}\frac{1}{3} mR^2\boldsymbol{\omega}^2$
Identifying factors that influence the rotational kinetic energy of an object	25	The following are 4 factors related to rotational dynamics: 1. The linear speed 2. The mass of object 3. The shape of object 4. The angular speed Based on the 4 factors mentioned above, the rotational kinetic energy of a rigid body depends on... A. 1, 2 and 4 B. 1, 2, and 3 C. 1 and 4 D. 2, 3, and 4 E. 3 and 4 Reason: A. The equation of rotational kinetic energy is $E_k = \frac{1}{2} mv^2$ B. The equation of rotational kinetic energy is $E_k = \frac{1}{2} mr^2$ C. The equation of rotational kinetic energy is $E_k = \frac{1}{2} l\omega^2$ D. The equation of rotational kinetic energy is $E_k = \frac{1}{2} l\omega^2 + \frac{1}{2} mv^2$ E. The equation of rotational kinetic energy is $E_k = l\omega^2$
Determining the rotational kinetic energy on a moving wheel	26	A wheel with a radius of 19 cm, and a mass of 4.5 kg used to transport the stone ruins of the temple, rotates at a speed of 50 rad/s. If the wheel is considered a thin hollow cylinder. The wheel's kinetic energy is …. A. 17 J B. 68 J

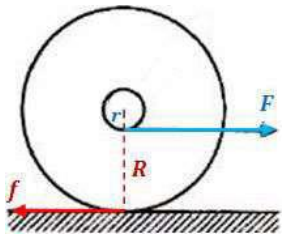
		C. 101 J D. 135 J E. 203 J Reason: A. The wheel rotational kinetic energy is $E_k = \frac{1}{2}\frac{1}{3}mr^2\omega^2$ B. The wheel rotational kinetic energy is $E_k = \frac{1}{2}\frac{1}{12}mr^2\omega^2$ C. The wheel rotational kinetic energy is $E_k = \frac{1}{2}mr^2\omega^2$. D. The wheel rotational kinetic energy is $E_k = \frac{1}{2}\frac{2}{3}mr^2\omega^2$. E. The wheel rotational kinetic energy is $E_k = \frac{1}{2}\frac{1}{2}mr^2\omega^2$.
Determining the amount of rotational kinetic energy on a moving wheel	27	When Prambanan Temple officers were cleaning the temple, he found a solid ball in the body of the temple. The solid ball has a mass of 0.2 kg and has a radius of 10 cm and rolls around the temple courtyard with a speed of 4 $\frac{\mathbf{m}}{\mathbf{s}}$. The kinetic energy of the orb is …. A. 2.24 J B. 2.25 J C. 2.26 J D. 2.27 J E. 2.28 J Reason: A. The kinetic energy acting on the event is rotational kinetic energy. B. The kinetic energy acting on the event is translational kinetic energy. C. The kinetic energy acting on the event is translational kinetic energy and rotational kinetic energy. D. The kinetic energy acting on the event is the difference between the initial rotational kinetic energy and the final rotational kinetic energy. E. The kinetic energy acting on the event is the difference between the initial translational kinetic energy and the final translational kinetic energy.
	28	A top with an inertia of 6×10^{-5}kg m^2 is carried out a constant torque of 2 I. The kinetic energy of the top after spinning for 10 s is … A. 0.00012 J B. 0.0012 J C. 0.012 J D. 0.12 J E. 1.2 J Reason: A. The product of the inertia with the torque is the kinetic energy of the rotation of a rigid body. B. The inertia for each unit of time is the kinetic energy of a rigid body rotation. C. The torque of each unit of time is the kinetic energy of the rotation of a rigid body. D. Kinetic energy is obtained from the amount of translational and rotational kinetic energy E. The kinetic energy of a rigid body that has the inertia 1 will rotate with a speed of ω
Sorting the speed of an	29	The three objects in the following figure have the same mass

object using the law of conservation of energy		and radius, except for the inner radius of the hollow cylinder. If the objects rotate downward down the inclined plane, the sequence of the first and the last objects arriving is....  A. The solid ball, the solid cylinder, and the hollow cylinder B. The solid cylinder, the hollow cylinder and the solid ball C. The hollow cylinder, the solid ball and the solid cylinder D. The solid cylinder, the solid ball and the hollow cylinder E. The hollow cylinder, the solid cylinder and the solid ball. Reason: A. The solid cylinder has the greatest inertia among the three objects, so that the speed is low. B. The hollow cylinder has the greatest inertia among the three objects, so the speed is high. C. The solid cylinder has the greatest inertia among the three objects, so that the speed is low. D. The solid cylinder has a small inertia between the three objects, so that the speed is high. E. The solid ball has the smallest inertia among the three objects, so the speed is high.
Calculating the angular acceleration of an object based on the equation of translational and rotational motion	30	A pulley system consisting of a solid cylinder with a mass of $2m$ and radius R is attached to a mass with a mass of m on the rope without mass regardless of friction. The system is then removed so that it moves from its stationary state. The acceleration of the angular rotation of the pulley is.... A. $\alpha = 5\frac{g}{R}$ B. $\alpha = \frac{4g}{2R}$ C. $\alpha = \frac{g}{R}$ D. $\alpha = \frac{g}{2R}$ E. $\alpha = \frac{g}{4R}$ Reason : A. The angular acceleration can be obtained using the rotational motion equation and the translational motion equation. B. The angular acceleration can be obtained using the rotational motion equation. C. The angular acceleration can be obtained using the translational motion equation. D. The angular acceleration can be obtained using the rotational kinetic energy equation. E. The angular acceleration can be obtained using a uniform circular motion equation.
	31	The children around the Plaosan temple are playing soccer. The ball is rolling on a sloping ground surface with a tilt angle θ. If the acceleration due to gravity is g, the linear acceleration of the sphere is ...

A. $\frac{3}{5} g \sin\theta$
B. $\frac{5}{7} g \sin\theta$
C. $\frac{3}{4} g \sin\theta$
D. $\frac{1}{2} g \sin\theta$
E. $\frac{2}{3} g \sin\theta$

Reason:
A. The linear acceleration of the ball is influenced by the inertia of $I = \frac{2}{3} mr^2$.
B. The linear acceleration of the ball is influenced by the inertia of $\boldsymbol{I = \frac{2}{5} mr^2}$.
C. The linear acceleration of the ball is influenced by the inertia of $I = \frac{1}{3} mr^2$.
D. The linear acceleration of the ball is influenced by the inertia of $I = mr^2$.
E. The linear acceleration of the ball is affected by the inertia of $I = \frac{1}{2} mr^2$.

32 A yoyo which has mass m drawn by an F style by a child rolls like in the picture. If it has an inertia of $I = \frac{1}{2} mR^2$ and the radius of 0.5 R, the angular acceleration of the yoyo is....

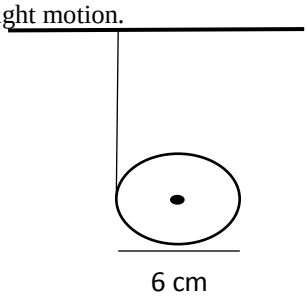


A. 0.29 $\frac{F}{mR}$
B. 0.30 $\frac{F}{mR}$
C. 0.32 $\frac{F}{m}$
D. 0.33 $\frac{F}{mR}$
E. 0.34 $\frac{F}{m}$

Reason :
A. On yoyo, rotational motion does not apply transalational motion.
B. On yoyo, the transalational motion does not apply.
C. The yoyo applies translational and rotational motion
D. The yoyo does not apply translational and rotational motion
E. The yoyo applies regular straight motion.

Calculating traditional game style moments based on translational and rotational equations

33 A yoyo with mass of 200 grams moves downward to escape from the string. If the yoyo's keeping is considered a solid wheel and the position of the thread is as shown, and the acceleration of the earth's gravity is 10 m / s ^ 2, the torque acting on the yoyo is ….



A. 0.02 Nm
B. 0.03 Nm
C. 0.04 Nm
D. 0.05 Nm
E. 0.06 Nm

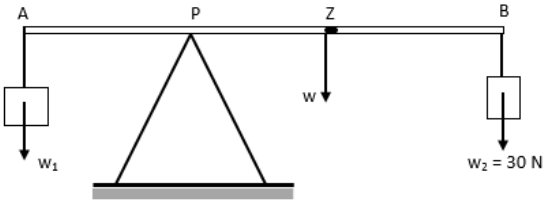
Reason:

		A. The torque acting on the yoyo can be obtained using the rotational equations. B. The torque acting on yoyo can be obtained using the translational motion equation. C. The torque acting on yoyo can be obtained using the rotational kinetic energy equation. D. The torque acting on the yoyo can be obtained using a uniform circular motion equation. E. The torque acting on the yoyo can be obtained using the equation of rotational motion and the translational motion equation.
Applying the equilibrium conditions of rigid body	34	If the number of torque on an object in a state of equilibrium is zero with respect to a given point, the amount of torque is …. A. Not zero towards all other points B. Zero with respect to all other points C. Zero with several other points D. Not zero towards some other point E. One against all other points Reason: A. The condition for a rigid body equilibrium is that the resultant force acting is nonzero ($\sum F_x \neq 0$; $\sum F_y \neq 0$) and the resultant torque acting is zero $\sum \tau (= 0)$. B. The condition for a rigid body equilibrium is that the resultant force acting is zero ($\sum F_x = 0$ $\sum F_y = 0$)) and the resultant t acting is not zero $\sum \tau \neq 0$) C. The condition for the occurrence of a rigid body equilibrium is that the resultant force acting is nonzero ($\sum F_x \neq 0$; $\sum F_y \neq 0$)) and the resultant moment of the force acting is not zero $\sum \tau \neq 0$) D. The condition for a rigid body equilibrium is that the resultant force acting is zero **(** $\sum F_x = 0$ $\sum F_y = \mathbf{0}$)) and the resultant torque acting is zero $\sum \tau (= 0)$. E. The condition for the occurrence of a rigid body equilibrium is that the resultant torque acting is not zero$\sum \tau \neq 0$).
Identifying factors affecting the equilibrium of an object	35	The following are 4 factors that affect the equilibrium of a rigid body. 1. The resultant force that reacts to objects 2. The shape of objects 3. The resultant moment of force reacts to the object 4. The size of objects Based on the 4 abovementioned factors, the factors that influence the equilibrium of the correct rigid body are... A. 3 and 4 B. 2 and 4 C. 1 and 2 D. 1 and 3 E. 2 and 3 Reason: A. The simultaneous moment of the reacting force is equal to zero and the larger the size of the object the greater the equilibrium. B. The simultaneous force reacting to objects is zero and each form of different object has a different equilibrium.

C. Each form of objects has a different equilibrium and the greater the size of the object the greater the equilibrium.
D. Each form of objects has a different equilibrium and the resultant torque reacting to the object is equal to zero.
E. The simultaneous force and the response of the torque reacting to the force is equal to zero.

Calculateing the gravity at the equilibrium of a rigid body

36 Homogeneous AB rod with a weight of 15 N, AB = 0.8 m, AP = 0.3 m, and P is the fulcrum as shown below.



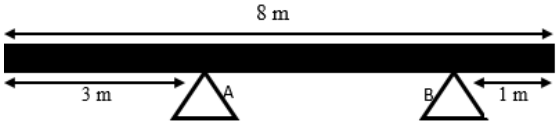
For AB rod to be balanced, the weight of load w1 must be...

A. 45 N
B. 55 N
C. 65 N
D. 75 N
E. 85 N

Reason:

A. Objects are said to be balanced if the amount of force is $(\sum F = 0)$.
B. Objects are said to be equal if the torque $(\sum \tau = 0)$ is equal to zero
C. Objects are said to be equal if the amount of force $(\sum \tau = 0)$ and the torque $(\sum \tau = 0)$ are equal to zero
D. Objects are balanced when they are at the equilibrium point of the rod.
E. The position of the rod does not affect the load lift.

37 A homogeneous wooden block that has a length of 8 m and a weight of 200 N is on two support poles A and B. The weight received by point A (in N) is …



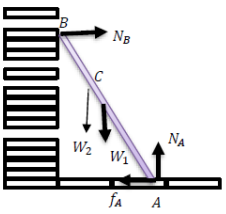
A. 120 N
B. 130 N
C. 140 N
D. 150 N
E. 160 N

Reason :

A. The force of each support is equal to half of the amount of gravity.
B. The support force A is the same as the support B because the force direction is the same.
C. The objects are said to be balanced if the sum of forces and the torque is zero.
D. The amount of torque is zero.
E. The amount of force is zero (regardless of the force direction).

Determining distance in traditional games

38 A seesaw has two fulcrum points such as an AC rod, with a mass of 40 kg and a length of 3 m. The footing distance of A

based on the principle of equilibrium of rigid body		and B is 2 m. A child weighing 25 kg walks from A to C. The distance of the child from point C to stay balanced is... A. 2 m B. 0.2 m C. 0.1 m D. 0.02 m E. 0.01 m Reason: A. The distance of BC is proportional to half of the child weight. B. The distance of BC is the same as AB because the force direction is the same. C. The amount of torque is equal to zero. D. The amount of forces is equal to zero (regardless of the force direction) E. The objects are said to be balanced if the sum of forces and the torque is equal to zero.
Determining the coefficient of friction based on the principle of equilibrium of rigid body	39	A ladder that is 5 m in length and 2 kg in mass rests on the Mendut temple wall by forming an angle of 53^o as shown. Just before the ladder slipped, a person whose mass of 50 kg had gone up as far as 3 meters from the end of the ladder. The coefficient of static friction between the ladder and the floor is.... (tan $\theta = \frac{3}{4}$) A. 1.00 B. 0.40 C. 0.30 D. 0.10 E. 0.20  Reason: A. The amount of the force in the same and opposite direction of the friction is zero. B. The friction and the coefficient is proportional to the ratio of the person's height going up and the length of the ladder. C. The equilibrium object is if the amount of forces and the torque are equal to zero. D. The frictional force and the coefficient are only influenced by the normal force on the friction plane. E. The frictional force is proportional to tan θ.
Applying rigid body balance		Look at the game table below!

Type of Activity	Picture	Activity Description
a. Stable Balance		Some children are playing marbles in the yard. The silent marbles are disturbed so that they move and their position remains balanced.
b. Unstable Balance		A top standing with a small section underneath when given a small disturbance cannot return to its original position.

		c. Neutral Balance  In the game Tekong/Tekong there are piles of broken tiles. The pile of broken tiles that have a point of equilibrium in the middle have little disturbance.	

The type of balance with the right example is ….

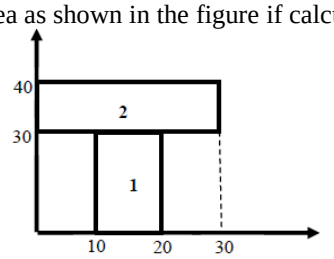
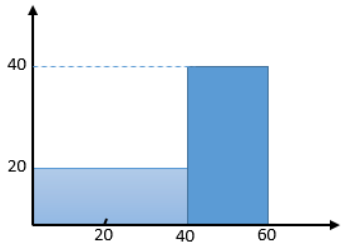
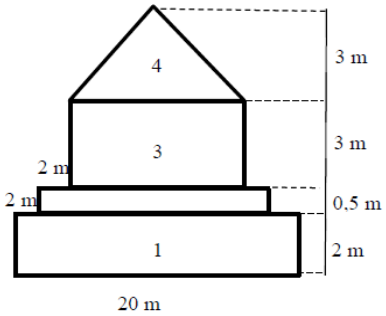
A. a
B. b
C. c
D. a and b
E. b and c

Reason:

A. Stable balance is the balance experienced by objects that when given a disturbance will move at a constant speed.
B. Unstable balance is a balance experienced by objects which if given a disturbance will not affect the equilibrium point of the object.
C. Neutral balance is the balance experienced by an object which if given a disturbance will not return to its original position.
D. Stable balance is the balance experienced by objects which if given a disturbance will not affect the equilibrium point of the object.
E. The unstable balance is the balance experienced by an object which, if given interference, the object will not return to its equilibrium position.

Identifying several rigid bodies to determine the type of equilibrium	41	Look at the picture below! 1. 2. 3.  Based on the image of the objects presented above, the correct sequence of objects in stable, unstable, and neutral equilibrium is. . . A. 1, 2, and 3 B. 2, 3, and 1 C. 3, 2, and 1 D. 2, 1, and 3 E. 1, 3, and 2 Reason: A. In Figure 1, if given a force then removed, then the ball will not return to its original position. In Figure 2, if given a force then removed, the ball will immediately return to its original position. In Figure 3, if given a force then removed, then the ball will move and stay in a different position. B. In Figure 1, if given a force then removed, the ball will immediately return to its original position. In Figure 2, if

		given a force and then removed, the ball will not return to its original position. In Figure 3, if given a force then removed, then the ball will move and stay in a different position. C. In Figure 1, if given a force then removed, then the ball will not return to its original position. In Figure 2, if given a force then removed, then the ball will move and still stand in a different position. In Figure 3, if given a force then removed, the ball will immediately return to its original position. D. In Figure 1, if given a force then removed, then the ball will move and stay in a different position. In Figure 2, if if given a force then removed, the ball will immediately return to its original position. Figure 3, if given a force then removed, then the ball will not return to its original position. E. In Figure 1, if given a force then removed, then the ball will not return to its original position. In Figure 2, if given a force then removed, the ball will immediately return to its original position. Figure 3, if given a force then removed, the ball will move and stay in the same position.
Identifying several rigid bodies to determine the type of equilibrium	42	In 2010, the Prambanan Temple was once shaken by a massive earthquake. There are some temple buildings tilted, but still stand firm. What causes this to happen is... A. The location of the mass center of the temple is still inside its base so that the tower remains in a stable condition. B. The location of the mass center of the temple has shifted so that the tower remains in a stable condition. C. The existence of gravity. D. The position of the center axis of the temple returns to its original position. E. The location of the mass axis center is not affected by the earthquake shocks. Reason: A. The building experiences stable equilibrium where if the object is subjected to force F, the object will remain in its original position. B. The building experiences neutral equilibrium in which if the object is subjected to force F, the object will remain stationary in the new position. C. The building experiences unstable equilibrium where if an object is subjected to force F, the object will fall and a new equilibrium will occur. D. The building experiences stable equilibrium where if the object is subjected to force F, the object will remain stationary in the new position. E. The building experiences neutral equilibrium where if an object is subjected to force F, the object will fall and a new equilibrium will occur.

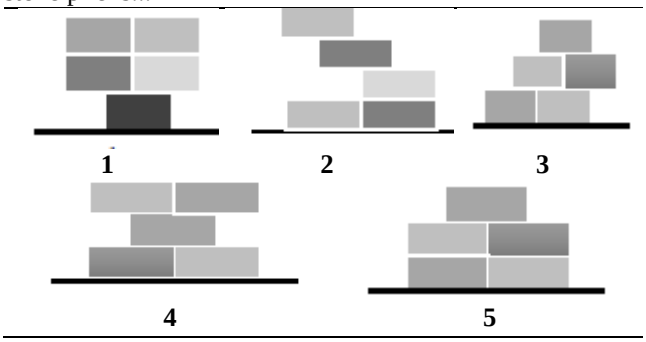
Calculating the center of gravity of an object in the form of an area	43	The location of the center of gravity of a plane in the form of an area as shown in the figure if calculated from point o is...  A. (x_0, y_0) = 10 m, 10 m B. (x_0, y_0) = 10 m, 20 m C. (x_0, y_0) = 15 m, 25 m D. (x_0, y_0) = 15 m, 10 m E. (x_0, y_0) = 25 m, 35 m Reason: A. The coordinat point of plane I (5;15) and plane II (15;35) B. The coordinat point of plane I (15;15) and plane II (15;35) C. The coordinat point of plane (15;15) and plane II (15;5) D. The coordinat point of plane (5;15) and plane II (15;5) E. The coordinat point of plane (20;30) and plane II (30;40)
	44	A homogeneous L-shaped carton is placed in a coordinate system. The gravity center of the carton is …. a. Z_0 = (35, 15) cm b. Z_0 = (30, 25) cm c. Z_0 = (22.5, 20) cm d. Z_0 = (15, 15) cm e. Z_0 = (12.5, 15) cm  Reason : a. The equilibrium coordinate point of object I is (20.10) and object II is (5.20) b. The equilibrium coordinate point of object I is (20.10) and object II is (30.20) c. The equilibrium coordinate point of object I is (40.20) and object II is (5.20) d. The equilibrium coordinate point of object I is (20.10) and object II is (50.20) e. The equilibrium coordinate point of object I is (40.10) and object II is (20.40)
	45	The location of the center of gravity of a building on the temple in the form of an area as shown in the figure if calculated from the base is... 

A. 3.13 m
B. 3.12 m
C. 2.97 m
D. 1.27 m
E. 1.12 m

Reason :

A. The center of gravity of the y-axis of I, II, III, and IV is 1 m; 0.25 m; 1.5 m; and 1 m.
B. The center of gravity of the y-axis of I, II, III, and IV is 1 m; 2.25 m; 4 m; and 6.5 m.
C. The center of gravity of the y-axis of I, II, III, and IV is 1 m; 2.25 m; 4 m; and 7 m.
D. The center of gravity of the y-axis of I, II, III, and IV is 1 m; 2.25 m; 1.5 m; and 1 m.
E. The center of gravity of the y-axis of I, II, III, and IV is 1 m; 0.25 m; 4 m; and 6.5 m.

46 Based on the following figure, the position of the more solid stone pile is...



A. Figure 1
B. Figure 2
C. Figure 3
D. Figure 4
E. Figure 5

Reason:

A. The center of gravity of Figure 4 is located in the center of the stone structure.
B. The center of gravity of the stone structure of Figure 2 is supported by a stable base plane.
C. The center of gravity of the stone structure of Figure 5 is supported by a stable base plane.
D. The center of gravity of the stone structure of Figure 3 is supported by a stable base plane.
E. The center of gravity of the stone structure of Figure 1 is in the middle of the stone structure

Calculateing the center of gravity of a homogeneous object

47 A plaosan lor temple stupa is arranged as shown below. The composition of the stupa consists of a solid cylinder and half solid ball at the top. If a solid cylinder has a radius of 30 cm and a height of 80 cm, while a half ball of solid has a radius of 30 cm, the location of the center of gravity of the stupa if calculated from the base of the cylinder is....

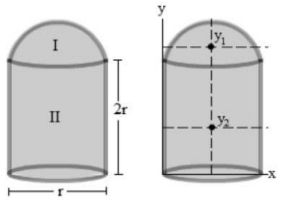
A. 43.01 cm
B. 61.96 cm
C. 30.50 cm
D. 21.45 cm

E. 50.25 cm

Reason :

A. The volume of object I is $V_1 = \pi r^2 t$ and the volume of object II is $V_2 = \frac{3}{4}\pi r^3$.
B. The volume of object I is $V_1 = \pi r^2 t$ and the volume of object II is $V_2 = 2\pi r^2$.
C. The volume of object I is $V_1 = \frac{1}{3}\pi r^2 t$ and the volume of object II is $V_2 = \frac{2}{3}\pi r^3$.
D. The volume of object I is $V_1 = \pi d^2 t$ and the volume of object II is $V_2 = \frac{2}{3}\pi r^3$.
E. The volume of object I is $\boldsymbol{V_1 = \pi r^2 t}$ and the volume of object II is $\boldsymbol{V_2 = \frac{2}{3}\pi r^3}$ **.**

48 The coordinates $Y1$ and $Y2$ of the volume object as shown below are ….

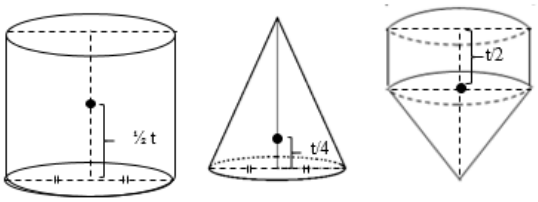


A. Y_1= (16⁄8 R) and Y_2= 2R
B. Y_1= (16⁄8 R) and Y_2= R
C. Y_1= (35⁄8 R) and Y_2= 3R
D. Y_1= (35⁄8 R) and Y_2= 2R
E. Y_1= (35⁄8 R) and Y_2= R

Reason:

A. The picture above is a combination of 2 objects and 1 half ball ($Y_1 = \frac{3}{8}R + 4R$) and 2 cylindrical object ($Y_2 = \frac{1}{2}t = \frac{1}{2}4R$).
B. The picture above is a combination of 2 objects and 1 half ball ($Y_1 = \frac{3}{8}R + 2R$) and 2 cylindrical object ($Y_2 = \frac{1}{2}t = \frac{1}{2}4R$)
C. The picture above is a combination of 2 objects and 1 half ball ($Y_1 = \frac{3}{8}R + 4R$) and 2 cylindrical object ($Y_2 = \frac{1}{2}t = \frac{1}{2}2R$)
D. The picture above is a combination of 2 objects and1 half ball ($Y_1 = \frac{3}{8}R + 2R$) and 2 cylindrical object ($Y_2 = \frac{1}{2}t = \frac{1}{2}2R$)
E. The picture above is a combination of 2 objects and 1 half ball ($Y_1 = \frac{3}{8}R + 2R$) and 2 cylindrical object ($Y_2 = \frac{1}{2}t = \frac{1}{2}6R$)

49 From the figure below, which one is the location of the gravity center of the top …

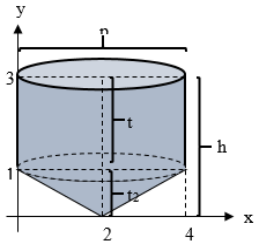


A. 1 and 2
B. 1 and 3
C. 1, 2, and 3
D. 2 and 3
E. 3 only

Reason:

A. The center of gravity of the cylindrical top is in the middle of the chamber, while the conical top is $\frac{1}{3}$t.
B. The center of gravity of the cylindrical top is in the middle of the chamber, while the conical top is $\frac{1}{3}$t, and the center of gravity of the combined cylinder and top is $\frac{1}{2}$t.
C. The center of gravity of the cylinder top is in the middle of the chamber, while the conical top is $\frac{1}{4}$t.
D. The center of gravity of the cylindrical top is in the middle of the chamber, while the conical top is $\frac{1}{3}$t, and the center of gravity of the combined cylinder and top is $\frac{1}{2}$t.
E. The center of gravity of the combined cylinder and conical top is $\frac{1}{2}$t.

50 Look at the picture below. The position of the center of gravity of the top is …



A. x_0 = 0.5 cm and y_0 = 1.5 cm
B. x_0 = 0.5 cm and y_0 = 18.2 cm
C. x_0 = 2 cm and y_0 = 1.5 cm
D. x_0 = 2 cm and y_0 = 3 cm
E. x_0 = 2 cm and y_0 = 1.75 cm

Reason:

A. The centrepiece of the top is at $x_0 = \frac{1}{2}.4$ cm and $y_0 = \frac{1}{2}.4$ cm.
B. The centrepiece of the top is a combination of the center of gravity of the cylinder ($x_1 = \frac{1}{2}.4$ cm and $y_1 = \frac{3}{2} + 1$) and the cone ($x_2 = \frac{1}{2}.4$ and $y_2 = \frac{1}{4}.1$) .
C. The centrepiece is at $x_0 = \frac{\sum A_i x_i}{\sum A_i}$ and $y_0 = \frac{\sum A_i y_i}{\sum A_i}$.

D. The centrepiece of the top is a combination of the cylinder's center of gravity ($x_1 = \frac{1}{2}$ .4 and $y_1 = \frac{3}{2}$) and the cone ($x_2 = \frac{1}{2}$. 4 and $y_2 = \frac{1}{3}$. 1).

E. The centrepiece of the top is at $x_0 = \frac{1}{2}$. 4 and $y_0 = \frac{2}{3}$4.

The scoring criteria used are based on the stages that students have completed. The highest score is of course obtained when the test taker answers correctly for the right reasons as well. According to Istiyono (2014), the assessment procedure is actually the same as when individuals respond to items in psychology. For example, the 4 categories, *never*, *rarely*, *often*, and *always* are analogous to the completion stage. Solving the problem only in the first stage (multiple choice answers are wrong and reasons are wrong too) is analogous to *never* category, whereas if solving until the final stage (multiple choice answers are correct and reasons are correct too), it is analogous to *always* category. This assumption is then developed into a Partial Credit Model (PCM). It is a development of the IRT 1 parameter of logistic (1-PL) model and is included in the Rasch Model (Wu & Adams, 2007).

The category score on PCM shows the number of steps to complete the item correctly. A higher category score indicates greater ability than a lower one. In PCM, if a test item has two categories, the probability equation becomes the Rasch model equation, as the equation stated by Hambleton and Swaminathan (1985). The scoring can follow the pattern of "0 0" for incorrect answer and reason, "1 0" for correct answer and ncorrect reason, "0 1" for incorrect answer and correct reason, and "1 1" for coccert answer and reason. Therefore, PCM is applied to politomus and dichotomous items. Chandrasegaran (2007) also states that the response is declared true if the multiple choice answer and the reason both are correct. The table below shows the number of students' or testi responses.

Table 4. Results of students' responses in each category

Item No.	Question & Incorrect Reason	Correct Reason	Correct Question	Question & Correct Reasons	Item No.	Question & Incorrect Reasons	Correct Reason	Correct Question	Question & Correct Reasons
1	172	30	217	61	26	353	73	18	36
2	82	46	334	18	27	192	80	124	84
3	139	87	144	110	28	302	11	41	126
4	213	78	150	39	29	309	53	74	44
5	195	66	168	51	30	298	78	28	76

Item No.	Question & Incorrect Reason	Correct Reason	Correct Question	Question & Correct Reasons	Item No.	Question & Incorrect Reasons	Correct Reason	Correct Question	Question & Correct Reasons
6	95	37	329	19	31	110	136	98	136
7	44	119	21	296	32	258	35	99	88
8	62	56	336	26	33	167	128	90	95
9	101	56	295	28	34	220	89	41	130
10	216	26	185	53	35	117	108	64	191
11	137	67	244	32	36	265	50	55	110
12	249	75	117	39	37	304	80	29	67
13	340	41	83	16	38	178	82	96	124
14	181	136	98	65	39	119	41	197	123
15	188	76	162	54	40	242	53	33	152
16	223	43	80	134	41	186	105	103	86
17	190	73	107	110	42	262	43	102	73
18	316	34	73	57	43	328	44	36	72
19	146	150	141	43	44	171	57	222	30
20	120	141	92	127	45	371	51	23	35
21	311	63	22	84	46	303	117	20	40
22	218	55	114	93	47	305	75	35	65
23	343	39	41	57	48	366	33	21	60
24	216	112	116	36	49	153	92	75	160
25	312	41	88	39	50	182	76	71	151

The data from the trial results were then analyzed using the Microsoft Excel, Quest, and Parscale Programs to determine their validity and reliability.

Validity Fill in Product Moment Correlation Coefficient

After getting the test results of 480 students, then the validity of the items with the Product Moment Correlation Coefficient was determined. The researcher determined the validity of items based on the Product Moment Correlation Coefficient using Microsoft Excel Program. The details of the Product Moment coefficient scores of each item are presented in Table 5.

Table 5. Product Moment Correlation Coefficients

Item No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Coefficient	0,19	0,35	0,48	0,33	0,33	0,43	0,28	0,37	0,19	0,44
Item No.	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Coefficient	0,45	0,48	0,39	0,29	0,57	0,52	0,4	0,36	0,12	0,3
Item No.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Coefficient	0,15	0,51	0,19	0,49	0,54	0,49	0,49	0,03	0,23	0,06
Item No.	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Coefficient	0,34	0,3	0,003	0,13	0,27	0,08	0,29	0,04	0,13	0,26
Item No.	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
Coefficient	0,18	0,12	0,57	0,52	0,29	0,38	0,35	0,005	0,34	0,33

Based on Table 5 above, there are 14 items that have the Product Moment Correlation Coefficient> 0.25 indicated by a red mark in the column. This indicates that these 14 items are invalid and there are 36 vald items based on Product Moment Correlation analysis. The invalid items may be revised or excluded from the measurement.

Reliability

The results of trials on 480 students were also used to determine the reliability of items. The researcher determine the reliabilty of items using the Quest and Parscale Program. The following the output of the reliability analysis using Quest.

The Quest program in determining Reliability has been adapted to the Alpha Cronbach formula for politomus response. The researcher also calculated the manual reliability using Microsoft Excel with the Cronbach Alpha formula. The calculation results show 0.816. These results are not much different even if they are rounded to two decimal places.

In addition to using the Quest Program, we can also see the reliability of an instrument using the Parscale program, which is based on the information function. The following is the output of data analysis using the Parscale program:

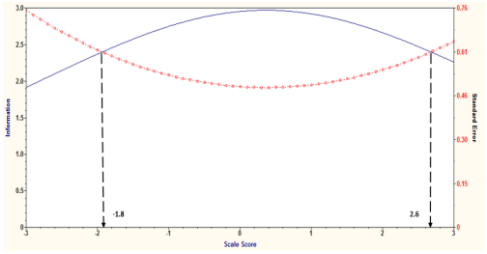


Figure 5. Information function and SEM

The test instrument reliability is strengthened by looking at the information function and Standard Error Measurement (SEM). Based on the information function and SEM stated in Figure 4, this assessment instrument is able to measure the students' ability in the high category, which is in the range of -1.8 to 2.6.

The assessment instrument developed has been integrated with the local local wisdom, in which there is no previous researcher that has developed a two-tier multiple-choice test by including any local wisdom. The program used to analyze the data from the results of trials using modern measurement theory programs are Parscale and Quest. The number of participants used for trial above 250 testees is about 480 testees, because the minimum limit for fulfilling the modern measurement theory is the 250 testees.

CONCLUSION

This assessment instrument will be used to measure the cognitive ability of high school students in physics subject on rigid body equilibrium and rotational dynamics. The number of

instrument items is 50 with close-reasoned multiple choice.

The content validity of the 50 instrument items based on the expert shows that 8 has a V-Aiken coefficient <0.78. This indicates that the item is invalid. The invalid item number are 3, 4, 7, 23, 29, 38, 42, and 50. The valid items based on content validity from experts are 42. The invalid items can be revised based on suggestions and input so that all items become valid. If it is not revised, the invalid items may not be included in the next process, which is the measurement process.

The content validity based on the Product Moment Correlation Coefficient was carried out after 50 instrument items were tested on 480 students. The analysis of the trial data shows that 14 items have a coefficient <0.25. This indicates that the 14 items are invalid. Details of the invalid item based on the Product Moment Coefficients are 1, 19, 21, 23, 28, 30, 33, 34, 36, 38, 39, 41, and 42. The invalid items can be revised based on suggestions and input so all items become valid. If it is not revised, the invalid items may not be included in the next process, which is the assessement process. The invalidity of the item could be due to the characteristics of the test or the instrument's item.

The item reliability of the student's cognitive ability assessment instrument shows the number 0.82 which the number is more than 0.70 and not more than 0.90. It indicates that the instrument is reliable or provides consistent results.

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