Research Paper   **Science**

Preparation and Testing of Mcq Bank Based on Some Physics Topics from Undergraduate Physics Course of University of Mumbai.

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ABSTRACT

This study focuses on testing of an MCQ bank based on some undergraduate Physics topics. Though MCQs have been popular as a quick discrimination device in various entrance examinations, such use is generally not preceded by a systematic testing of MCQ items. The MCQs used are mostly a compilation from disparate sources which are then directly used as a discrimination device. Internationally, careful use of pre- tested MCQ items is in fact a norm. In order to carry out a systemic investigation of a multiple choice question bank based on Classical Test Theory[1] we prepared a MCQ bank of 50 items. Students then took this test which generated a data which was analysed using item analysis technique.

Methodology:-

i) Sample

The sample for the study comprised of students of B.Sc. course of University of Mumbai. A total of 86 students volunteered for the study. Students were expected to complete this 50 item MCQ bank in Physics in 60 minutes.

ii) Topics selected and preparation of the MCQ items

The MCQ items in the bank are based on Elasticity, Viscosity, Newton's Laws of Motion and Ray Optics, topics of Undergraduate Physics Course of University of Mumbai. It must be mentioned here, that this is a representative selection of topics in the subject. The scope of work does not allow inclusion of more topics which might be necessary. This may be the limitation of the study.

Appropriate care was taken to prepare items in such a way that they address students capacity to remember, understand, apply and analyze.

Out of 50 items included in the MCQ bank, 10 are memory based, 21 are understanding oriented, 10 based on application of concepts, and 9 are based on students' analytical skills.

ii) Generation of Data

Students' responses to this test are our data. This data was subjected to item analysis and test analysis as enumerated in Classical Test Theory[1]. This theory recommends following indices for item analysis—

Item Difficulty Level: P, Item Discrimination Index : D, Point Biserial Coefficient :r_{pbi}

For test analysis two more indices have been proposed:—

Kuder – Richardson Index :r_{test} and Ferguson's Delta : δ

iv) Computation of indices

The 50 by 86 matrix (comprising of 0s for wrong and 1s for correct response) was used to compute the indices listed for all 50 items(cycle I). After careful scrutiny of the item indices, individual items were divided into two categories.

Dropped items and **Revised Items**.

It was learnt from this analysis that certain items are required to be omitted or redesigned in order to make them more suitable to students. Four items had to be dropped and a total of 12 items were redesigned and were once again merged into the original MCQ bank making a revised set of 46. All the indices were recalculated and then MCQ bank was revised to make it a set of 46 items (cycle II).

DATA ANALYSIS

(I)DROPPED ITEMS

Following items were dropped from the list as their D and r_{pbi} were either negative or very low. Item Nos. 3, 7, 13, 17, 24, 37.

Item No. 3) The Young's modulus of air is . . . .

a) Infinity   b) less than 1 but not zero   c) more than 1 but not infinity   d) zero

Remark: Actually, Young's Modulus for air is not defined, so such an item should not have been included in the first place.

Item No. 13) The Young's modulus of a perfectly rigid body is . . . .

a) 1   b) cannot be defined   c) infinite   d) zero

Remark: This item requires understanding that Y(Young's Modulus) definition which requires Hooke's Law to be obeyed. There are too many implicit assumptions in the stem which might have confused the students. So it has been dropped.

Item No. 17) Under a constant pressure head, the rate of flow of volume, flow of liquid through a capillary tube is Q if the length of capillary is doubled and the diameter of the bore is halved the rate of flow would become . . . .

a) $\dfrac{Q}{32}$ b) $\dfrac{Q}{8}$ c) $\dfrac{Q}{4}$ d) 16Q

Remark: The wording is confusing. The formula for rate of flow of liquid should have been provided, which is, $V = \dfrac{Q}{t} = \dfrac{\pi (P_1 - P_2)a^4}{8\eta l}$ Again like a small problem so should be dropped.

Item No. 24) A solid is completely immersed in a liquid. The force exerted by the liquid on the solid will . . . .

a) be in the vertically upward direction

b) change if its orientation is changed

c) decreases if it is taken partially out of the liquid

d) increase if it is pushed deeper in the liquid

Remark: More than one correct option so should be dropped.

Item No. 37) Two wooden blocks are moving on a smooth horizontal surface such that the mass m remains stationary with respect to block of mass M as shown in following figure. The magnitude of force F is . . . .

a) g tan α b) mg cos α c) (M + m) cosec α d) (M + m)g tan α
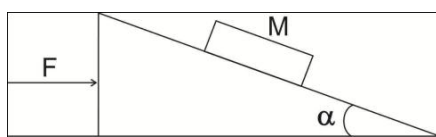
Remark: Wrong diagram appeared in this item by mistake which confused the students. So it should be dropped.

(II)REVISED ITEMS AND IMPROVED INDICES:

Item No. 9) Theoretical value of Poisson's ratio lies between . . . .

a) -1 and 0.5   b) 0.5 and 1   c) 0 and 0.5   d) -1 and 1

Indices: P = 0.28   D = 0.19 r_{pbi} = 0.2

Remark: This is a memory based item. It has borderline values of both P and D. This may be because students might not have retained the vital numbers. The item is retained in spite of borderline performance as it has a clear cut composition.

Item No. 16) A wooden block is floating in a trough of water. If the trough falls freely, the upward thrust on the wooden block will be . . . .

a) more than earlier   b) same as before   c) zero   d) equal to the weight of the block in air

Indices: P = 0.15   D = 0.28 r_{pbi} = 0.45

Remark: Word 'trough' should be replaced by bucket. The item to be reworded as follows. A wooden block is floating in a bucket of water. The weight of the block in air is W. This wooden block, experiences an upthrust U when the bucket is at rest. When this bucket falls freely under gravity the upthrust becomes U′.Then-

a) U′> U   b) U′ = U   c) U′ = 0   d) U′ = W

Item No. 19) Which one of the following substances, has the greatest viscosity? . . . .

a) hydrogen   b) mercury   c) oxygen   d) water

Indices: P = 0.49   D = 0.28 r_{pbi} = 0.19

Remark: This item has very good P and slightly low D and r_{pbi}. This is perhaps due to a fact that two gases Oxygen and Hydrogen appear as distracters. Their viscosity is of different nature than that of mercury and water. Therefore, the options should be changed as-

a) hydrogen   b) mercury   c) gum   d) water

Thereafter, item was retained

Item No. 23) With the increase in temperature, the viscosity of . . . .

a) both gases and liquid decreases   b) both gases and liquid increases

c) gases decreases and liquid increases   d) gases increases and liquid decreases

Indices: P = 0.19   D = 0.05 r_{pbi} = 0.15   (old indices retained)

Remark: This is a memory based item. It's a good item. Well worded but the students might have forgotten the content so the low scores. Still merits retention.

Item No. 30) Reaction due to a body depends on its . . . .

a) acceleration   b) mass   c) velocity

Indices: P = 0.37   D = 0.28 r_{pbi} = 0.19

Remark: This item has desirable P but slightly low D and r. The item requires rewording as it is too short. It does not provide enough information. Reworded item should be as follows-

 A body moves on a frictionless surface. Reaction (N) acting on this body depends on, body's

a) acceleration   b) mass   c) velocity   d) density

Item No. 31) A particle is acted upon by a force of constant magnitude which is always perpendicular to the velocity of the particle. The motion of the particle takes place in a plane. It follows that   . . . .

a) its acceleration is constant   b) its KE is constant

c) it moves in circular path   d) its velocity is constant

Indices: Here, P = 0.29   D = 0.23 r_{pbi} = 0.19

Remark: More than one items are correct. It's too confusing. The item requires rewording.

A particle is acted upon by a constant force, which is always perpendicular to the velocity of a particle at every point of its path. This path shall be-

a) straight line   b) circular   c) spiral   d) elliptical

Item No. 32) When a bicycle is in motion, the force of friction exerted by the ground on the two wheels in such that it acts . . . .

a) in the backward direction on both the wheels

b) in the backward direction on the front wheel and in the forward direction on the rear wheel

c) in the forward direction on both the wheels

d) in the forward direction on the front wheel and in the backward direction on the rear wheel

Indices: P = 0.21   D = 0.19 r_{pbi} = 0.29

Remark: The item requires rewording as follows, as D is very low but $r_{pbi\ is}$ satisfactory.

Man is riding a bicycle on a rough surface. The direction of force of friction at the point of contact will be –

a) in the backward direction on both the wheels

b) in the backward direction on the front wheel and in the forward direction on the rear wheel

c) in the forward direction on both the wheels

d) in the forward direction on the front wheel and in the backward direction on the rear wheel

Item No. 33) Passengers standing in a bus are thrown outward when the bus takes a turn suddenly. This happens because of . . . .

a) change in acceleration   b) change in momentum   c) inertia   d) outward pull on them

Indices: P = 0.38   D = 0.19 r_{pbi} = 0.21

Remark: Indices P and r_{pbi} are satisfactory but D = 0.19 is low. The options should be changed as under.

A passenger standing in a bus is thrown outward when the bus takes a sudden turn. This happens because of

a) acceleration of the bus   b) inertia of a passenger

c) momentum of the bus   d) weight of a passenger

Item No. 35) In which of the following cases the net force is not zero? . . . .

a) a ball freely falling from a height

b) a cork floating on the surface of water

c) a kite skilfully held stationary in the sky

d) an aeroplane rising upwards at an angle of 45degrees with the horizontal with a constant speed

Indices: P = 0.28   D = 0.23 r_{pbi} = 0.14

Remark: All indices are low. Too many complex situations confronting the students here. The option (d) needs to be changed. Also the 45 degrees angle may be proving to be additional distracter. Revised option (d) should be d) a hot air balloon suspended in mid air

Item No. 38) A mass m rests on a horizontal surface. The coefficient of friction between the mass and the surface is μ. If the mass is pulled by a force F as shown in following figure the limiting friction between mass and the surface will be . . . .
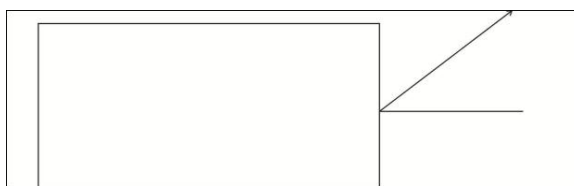
a) μmg b) $\mu\left[mg - \dfrac{\sqrt{3}}{2}F\right]$ c) $\mu\left[mg - \dfrac{F}{2}\right]$ d) $\mu\left[mg + \dfrac{F}{2}\right]$

Indices: P = 0.26   D = 0.23 r_{pbi} = 0.27

Remark: All indices are low. The diagram should be changed as given below such that it provides more information.
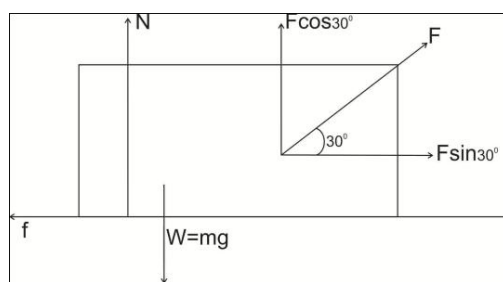
Item No. 41) A lens is called as 'thin lens' if . . . .

i) its thickness is small compared to its radius of curvature

ii) its thickness is small compared to its object distance

iii) its thickness is small compared to its image distance

a) i, ii, iii   b) Only i   c) Only i, iii   d) Only iii

Indices: P = 0.28   D = 0.23 r_{pbi} = 0.17

Remark: All indices lower than desirable values. The stem of this item is too small and option too long.

A lens is called as 'thin lens' if its thickness is small compared to--

i) its radius of curvature   ii) its object distance   iii) its image distance

a) i, ii, iii   b) Only i   c) Only i, iii   d) Only iii

Item No. 43) The deviation δ produced by a thin convex lens is independent of . . . .

a) focal length – f   b) height – h   c) position of object – u

Indices: P = 0.36   D = 0.19 r_{pbi} = 0.18

Remark: Fourth option should be included. d) position of image – v

**Item No**. 44) A bi-convex lens is kept in a uniform medium then . . . .

i) two conjugate focal lengths on either side are equal

ii) two conjugate focal length on either side shall have opposite signs

a) bothi , ii true   b) only i is true   c) only ii is true

Indices: P = 0.36   D = 0.05 r_{pbi} = 0.17 (old indices retained)

Remark: There was no need to introduce 'conjugate' term here. The use of this term must have acted like a distracter. We should just drop the term 'conjugate' and retain this item in the bank with a fourth option d) both i,ii are false.

Item No. 45)
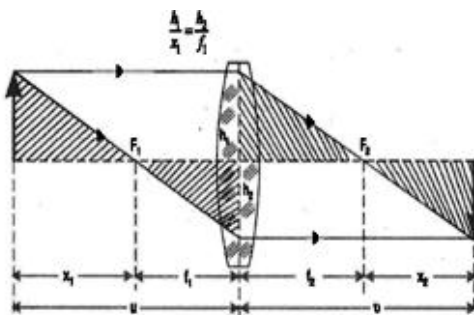
 For the diagram above, choose one of the sign convention . . . .

a) x_1 -ve , f_1 -ve , x_2 +ve , f_2 -ve   b) x_1 -ve , f_1 +ve , x_2 +ve , f_2 +ve

c) x_1 +ve , f_1 +ve , x_2 -ve , f_2 –ve   d) x_1 +ve , f_1 -ve , x_2 -ve , f_2 +ve

Indices: P = 0.33   D = 0.19 r_{pbi} = 0.19

Remark: The direction of the ray should have been indicated which will help improve students' performance in the item.

Item No. 49) A convex lens has freal length f_a in air. Its focal length in water will be f_w

a) f_w = 1.33 f_a b) f_w = f_a c) $f_a > f_w$ d) $f_w > f_a$

Indices: P = 0.23   D = 0.00 r_{pbi} = 0.11 (old indices retained)

Remark: Spelling mistake 'freal' for "focal" rendered the item meaningless, so we got low scores for this item. Therefore appropriate correction must be made and the item should be retained

Experimental Data

Test Statistics	Initial Indices (Cycle I)	Improved Indices (Cycle II)	Desired Values
Item Difficulty Level (P)	0.34	0.36	[0.30-0.90]
Discrimination Index (D)	0.25	0.33	>=0.30
Point Biserial Coefficient (r_{pbi})	0.27	0.29	>=0.20

Reliability Index (r_{test})	0.69	0.72	>=0.70
Ferguson's Delta (δ)	0.95	1.02	>=0.90

Discussion of Results and Conclusion

The indices of item analysis and test analysis referred here provide information about suitability or otherwise of a given item under consideration. It also comes out from this study that the process of designing the MCQ bank is an iterative one. This is because it is seen that from cycle I to cycle II there is an overall improvement in the indices.It is seen that the difficulty and discrimination indices have marginally improved but Reliability Index and Ferguson's delta show good improvement indicating that the MCQ bank has become more cohesive.

REFERENCES

1. Lin Ding & Robert Beichner, Approaches to data analysis of multiple choice questions, PHYS. REV. ST PHYS. EDUC. RES. 5 020203 (2009).