Assessing the Assessments: Physics

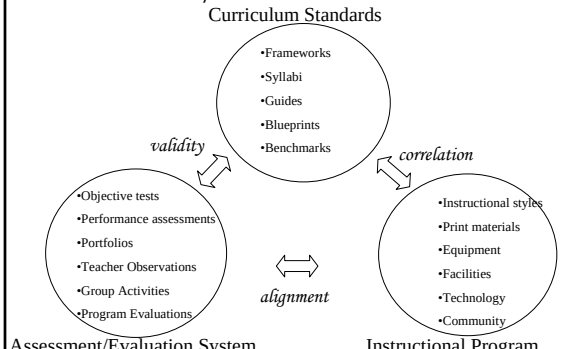
An Analysis of the June 2004 NYS Regents Physics Exam

J. Zawicki, SUNY Buffalo State College
M. Jabot, SUNY Fredonia

Assessment Purposes

- Measure knowledge
- Measure gain in knowledge
- Measure preparation (predict success)
- Sorting (Grading)
- Degree requirements (benchmarks)
- …

Curriculum, Assessment and Instruction



Concepts (Continued)

- Difficulty – (Percentage or proportion that are successful on an item)
  - Facility
  - Difficulty
- Discrimination – (How well does the item differentiate between students who understand the subject and those who do not?)

Concepts

- Validity – how well the item measures match the target construct. May be qualified as:
  - Construct
  - Content (Face)
  - Criterion Related
- Typically determined by a panel of experts

Concepts (Continued)

- Reliability – can the results be replicated?
  - Inter-rater (Do two or more raters agree on the score for an item?)
  - Test/Re-test (Will a student earn similar scores on different administrations?)
  - Internal Consistency
- Criterion referenced tests – have the students met the “standard”

Concepts (Continued)

- Latency – (How long do students take to complete the test?)
- Equitable (Fair)
- Timed tests (Power tests)

Types of Analysis

- Traditional (difficulty, discrimination)
- Rasch Analysis (item difficulty is equated to student ability)
- Cognitive Level (Bloom's taxonomy simplified: knowing, using, integrating)

Initial Analysis

Item	*Key*	*R/C 1*	*R/C 2*	*R/C 3*	*R/C 4*	*Facility*	*Difficulty*	*Difficulty Estimate*	*P*
1	4	1	1	1	192	0.98	0.02	-4.16	0.99
39	1	189	4	1	0	0.97	0.03	-3.45	0.97
11	4	5	1	10	179	0.92	0.08	-2.41	0.92
6	1	173	12	9	1	0.89	0.11	-2.06	0.89
12	2	4	171	20	0	0.88	0.12	-1.96	0.88
36	4	45	18	49	83	0.43	0.57	0.30	0.43
17	2	6	74	3	112	0.38	0.62	0.49	0.39
28	1	72	103	10	10	0.37	0.63	0.54	0.38
46	4	80	26	20	66	0.34	0.66	0.67	0.34
20	3	30	6	60	99	0.31	0.69	0.81	0.31

Initial Analysis

Item	*Credit*	*R/C 0*	*R/C 1*	*R/C 2*	*Facility*	*Discrimination*	*Difficulty Estimate*	*p*
60	1	2	69	1	0.36	0.64	0.56	0.32
63	2	3	2	66	0.35	0.65	0.61	0.31
61	1	6	65	1	0.34	0.66	0.65	0.30
58	2	7	4	61	0.32	0.68	0.74	0.28
70	1	12	59	1	0.31	0.69	0.79	0.27
64	1	33	39	0	0.20	0.80	1.39	0.17
68	2	40	8	24	0.14	0.86	1.79	0.12
56	2	19	53	0	0.14	0.86	1.85	0.12
54	2	31	41	0	0.11	0.89	2.14	0.09
55	1	59	12	1	0.07	0.93	2.56	0.06

Difficulty Rankings

- Easier MC: 1, 39, 11, 6, 12
- More Difficult MC: 20, 46, 28, 17, 36

Easier Multiple Choice

1 Velocity is to speed as displacement is to

(1) acceleration (3) momentum
(2) time (4) distance

Easier Multiple Choice

Base your answers to questions 39 and 40 on the data table below. The data table lists the energy and corresponding frequency of five photons.

Photon	Energy (J)	Frequency (Hz)
A	6.63×10^{-15}	1.00×10^{19}
B	1.99×10^{-17}	3.00×10^{16}
C	3.49×10^{-19}	5.26×10^{14}
D	1.33×10^{-20}	2.00×10^{13}
E	6.63×10^{-26}	1.00×10^{8}

39 In which part of the electromagnetic spectrum would photon *D* be found?

(1) infrared (3) ultraviolet
(2) visible (4) x ray

Easier Multiple Choice

11 The work done in moving a block across a rough surface and the heat energy gained by the block can both be measured in

(1) watts (3) newtons
(2) degrees (4) joules

Easier Multiple Choice

6 The acceleration due to gravity on the surface of planet *X* is 19.6 meters per second^2. If an object on the surface of this planet weighs 980. newtons, the mass of the object is

(1) 50.0 kg (3) 490. N
(2) 100. kg (4) 908 N

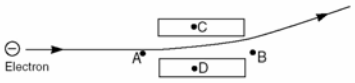
Easier Multiple Choice

12 Two weightlifters, one 1.5 meters tall and one 2.0 meters tall, raise identical 50.-kilogram masses above their heads. Compared to the work done by the weightlifter who is 1.5 meters tall, the work done by the weightlifter who is 2.0 meters tall is

(1) less
(2) greater
(3) the same

More Difficult Multiple Choice

20 A moving electron is deflected by two oppositely charged parallel plates, as shown in the diagram below.

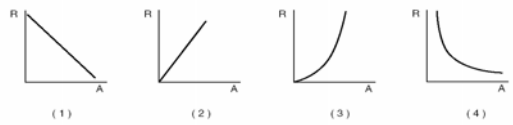


The electric field between the plates is directed from

(1) A to B
(2) B to A
(3) C to D
(4) D to C

More Difficult Multiple Choice

46 Several pieces of copper wire, all having the same length but different diameters, are kept at room temperature. Which graph best represents the resistance, R, of the wires as a function of their cross-sectional areas, A?



More Difficult Multiple Choice

28 As a sound wave passes from water, where the speed is 1.49×10^3 meters per second, into air, the wave's speed

(1) decreases and its frequency remains the same
(2) increases and its frequency remains the same
(3) remains the same and its frequency decreases
(4) remains the same and its frequency increases

More Difficult Multiple Choice

17 A negatively charged plastic comb is brought close to, but does not touch, a small piece of paper. If the comb and the paper are attracted to each other, the charge on the paper

(1) may be negative or neutral
(2) may be positive or neutral
(3) must be negative
(4) must be positive

More Difficult Multiple Choice

36 A constant unbalanced force is applied to an object for a period of time. Which graph best represents the acceleration of the object as a function of elapsed time?

Easier Constructed Response

Base your answers to questions 60 through 62 on the information and data table below.

In an experiment, a student applied various forces to a spring and measured the spring's corresponding elongation. The table below shows his data.

Force (newtons)	Elongation (meters)
0	0
1.0	0.30
3.0	0.67
4.0	1.00
5.0	1.30
6.0	1.50

60 On the grid provided *in your answer booklet*, plot the data points for force versus elongation. [1]

Easier Constructed Response

Base your answers to questions 63 and 64 on the information below.

A physics class is to design an experiment to determine the acceleration of a student on in-line skates coasting straight down a gentle incline. The incline has a constant slope. The students have tape measures, traffic cones, and stopwatches.

63 Describe a procedure to obtain the measurements necessary for this experiment. [2]

Easier Constructed Response

In an experiment, a student applied various forces to a spring and measured the spring's corresponding elongation. The table below shows his data.

Force (newtons)	Elongation (meters)
0	0
1.0	0.30
3.0	0.67
4.0	1.00
5.0	1.30
6.0	1.50

60 On the grid provided *in your answer booklet*, plot the data points for force versus elongation. [1]

61 Draw the best-fit line. [1]

Easier Constructed Response

58 A beam of light travels through medium *X* with a speed of 1.80×10^8 meters per second. Calculate the absolute index of refraction of medium *X*. [Show all work, including the equation and substitution with units.] [2]

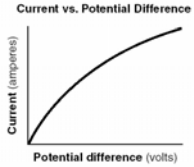
Easier Constructed Response

70 It has been suggested that fire trucks be painted yellow green instead of red. Using information from the graph, explain the advantage of using yellow-green paint. [1]

More Difficult Constructed Response

Base your answers to questions 53 through 55 on the information and graph below.

A student conducted an experiment to determine the resistance of a lightbulb. As she applied various potential differences to the bulb, she recorded the voltages and corresponding currents and constructed the graph below.



55 While performing the experiment the student noticed that the lightbulb began to glow and became brighter as she increased the voltage. Of the factors affecting resistance, which factor caused the greatest change in the resistance of the bulb during her experiment? [1]

More Difficult Constructed Response

54 According to the graph, as the potential difference increased, the resistance of the lightbulb

(1) decreased
(2) increased
(3) changed, but there is not enough information to know which way

More Difficult Constructed Response

A student plucks a guitar string and the vibrations produce a sound wave with a frequency of 650 hertz.

56 The sound wave produced can best be described as a

(1) transverse wave of constant amplitude
(2) longitudinal wave of constant frequency
(3) mechanical wave of varying frequency
(4) electromagnetic wave of varying wavelengths

More Difficult Constructed Response

Base your answers to questions 65 through 68 on the information below.

The driver of a car made an emergency stop on a straight horizontal road. The wheels locked and the car skidded to a stop. The marks made by the rubber tires on the dry asphalt are 16 meters long, and the car's mass is 1200 kilograms.

68 Assuming that energy is conserved, calculate the speed of the car before the brakes were applied. [Show all work, including the equation and substitution with units.] [2]

More Difficult Constructed Response

A physics class is to design an experiment to determine the acceleration of a student on in-line skates coasting straight down a gentle incline. The incline has a constant slope. The students have tape measures, traffic cones, and stopwatches.

64 Indicate which equation(s) they should use to determine the student's acceleration. [1]

Common Threads – Easier Items

- Graphing
- Using charts, tables, graphs
- Classification (vectors, scalars, …)

Common Threads – More Difficult Items

- Mathematical relationships (Modeling)
  - Direct
  - Inverse
  - Linear
  - Exponential
- Electric, Magnetic, and Gravitational Interactions; Fields (CSEM, Modeling, Castle, Knight)
- Energy vs. Force (FCI, PET, Modeling)

Next Steps

- Questions
- Implications for classrooms (program review)
- Additional Resources
  - BSC: SCI685, Evaluation in Science Education
  - SUNY Fredonia: EDU503, Evaluation in the Schools
  - SUNY Buffalo: LAI534, Measurement & Evaluation Of Science Instruction
  - STANYS 2004 Annual Conference, November 7-9, 2004
  - Rochester Science Educator's Conference
  - NYSSELA *Perspectives*