

# What can we learn from and about free-response assessment questions in physics?

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# Concept Inventory



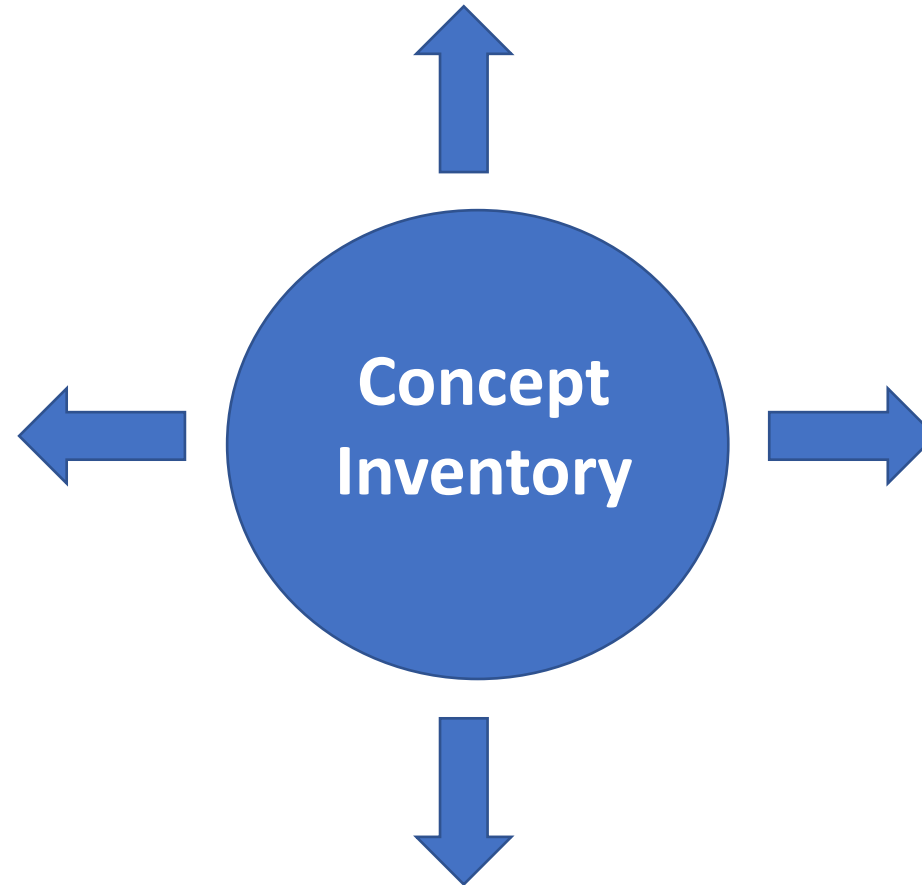
- In the simplest terms, a concept inventory is an outline of core knowledge and concepts for a given field.
- Concept inventories are collection of multiple-choice questions that are designed to probe students' understanding of fundamental concepts.
- The questions are designed to assess students' qualitative understanding of concepts, rather than their ability to solve quantitative problems.

To inform changes in instruction from year to year

To assess student learning during a course, module or activity

Pre/Post assesment

Identify demographic variables (e.g. ethnicity, gender, etc.)



To identify key misconceptions students hold about an evolutionary topic.

For measuring student knowledge in a topic before a course or module

## The Force Concept Inventory

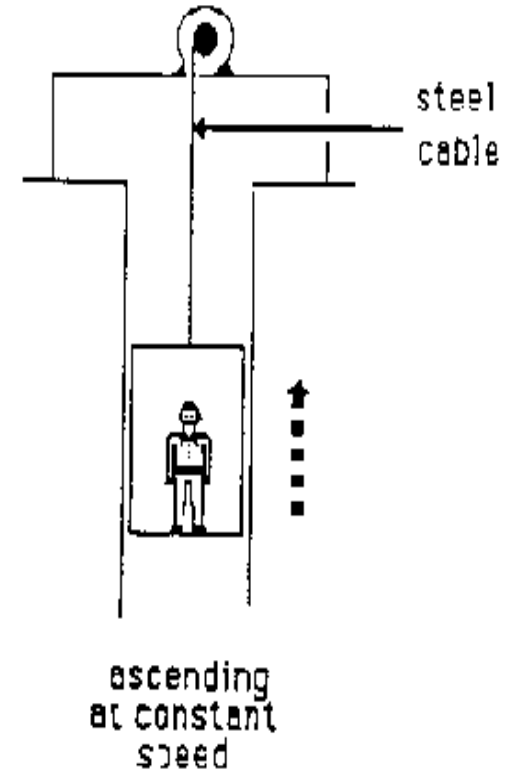
- The Force Concept Inventory (FCI) is an instrument designed to probe students' misconceptions about force and motion.
- The FCI consists of 30 multiple-choice questions.
- Major common-sense categories covered in the FCI are as followed

|                                |                               |
|--------------------------------|-------------------------------|
| 1. Kinematics                  | 2. Impetus                    |
| 3. Active Forces               | 4. Action-reaction pair       |
| 5. Concatenation of influences | 6. Other influences of motion |

## Example...

An elevator, as illustrated, is being **lifted up** an elevator shaft by a steel cable. When the elevator is moving up the shaft at a **constant velocity**;

- (A) the upward force on the elevator by the cable is greater than the downward force of gravity.
- (B) the amount of upward force on the elevator by the cable is equal to that of the downward force of gravity.
- (C) the upward force on the elevator by the cable is less than the downward force of gravity.
- (D) it goes up because the cable is being shortened, not because of the force being exerted on the elevator by the cable.
- (E) the upward force on the elevator by the cable is greater than the downward force due to the combined effects of air pressure and the force of gravity.



**Option B**

- Hestenes et al. claim that the FCI overall is a very good Newtonian thinking detector and that **errors** (false positive or false negative) on the inventory are more insightful than the **correct** selections.
- In a good multiple-choice question (MCQ), all choices should be well defined and mutually exclusive, with each choice representing a plausible response. However, it has been found that the most of the FCI questions are not in agreement with the definition.

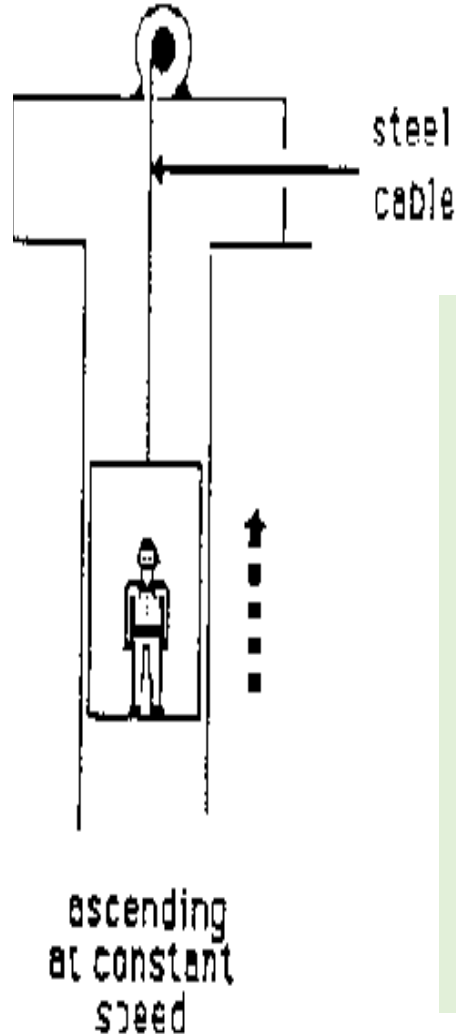
**Well, is there any alternative of MCQ based Force concept inventory?**



## Free-response Version of the Elevator Problem

**Q.** An elevator, as illustrated, is being **lifted up** an elevator shaft by a steel cable. When the elevator is moving up the shaft at a **constant velocity**;

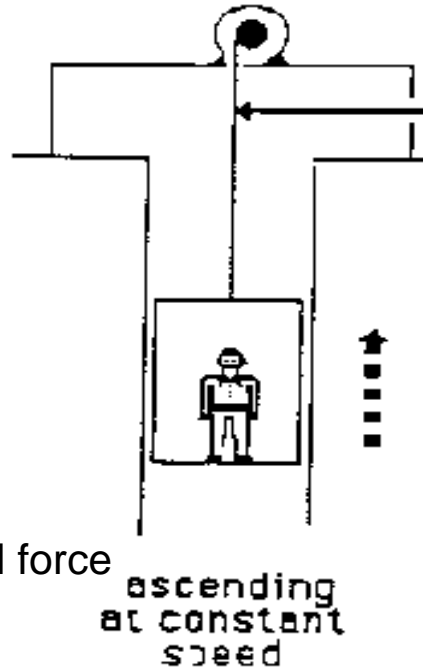
- (A) the upward force on the elevator by the cable is greater than the downward force of gravity.
- (B) the amount of upward force on the elevator by the cable is equal to that of the downward force of gravity.
- (C) the upward force on the elevator by the cable is less than the downward force of gravity.
- (D) it goes up because the cable is being shortened, not because of the force being exerted on the elevator by the cable.
- (E) the upward force on the elevator by the cable is greater than the downward force due to the combined effects of air pressure and the force of gravity.



1. In the diagram below, an elevator is being hauled up by a shaft at a constant speed by a steel cable. All frictional effects are negligible. Identify the forces acting on the elevator.
2. Recall that the lift is going up in the shaft at a constant speed. What does it tell you about the forces acting on the lift?

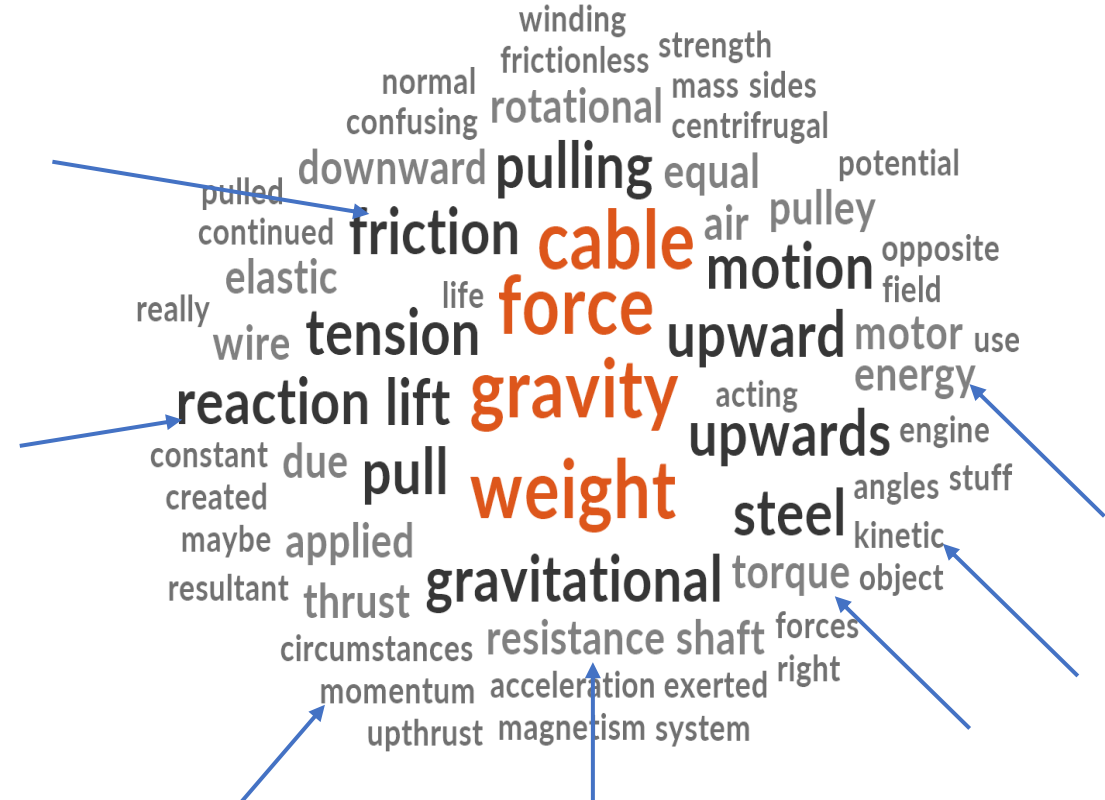
# Keywords-in-Context Analysis

- In the diagram below, an elevator is being hauled up by a shaft at a constant speed by a steel cable. All frictional effects are negligible. Identify the forces acting on the elevator.



Some of the answers are as follows;

- downward weight upward: upward force
- DOWNWARD GRAVITY
- reaction force weight friction
- Gravitational potential energy Gravity Kinetic energy
- Gravity friction air resistance





## Keywords-in-Context Analysis

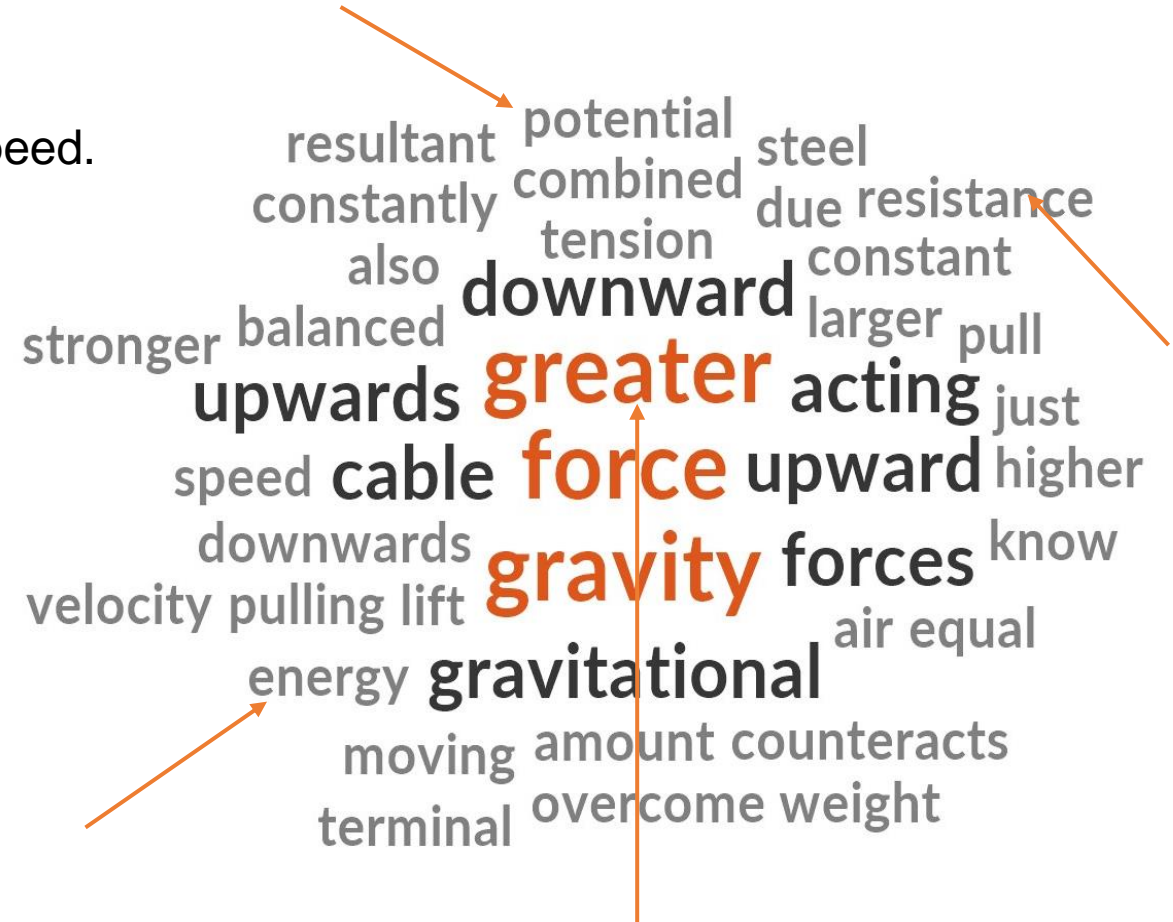
2. Recall that the lift is going up in the shaft at a constant speed. What does it tell you about the forces acting on the lift?

Some of the answers are as follows;

- i. Gravitational potential energy is greater than that from the force of gravity
- ii. steel cable force greater than gravity
- iii. the upward force by the cable is greater than the downward force of gravity.
- iv. the force of the cable is greater then the gravitational force and also moving at a constant spee

Total 275 responses were collected across the sections in 2019

1. [Pattern-match question type – MoodleDocs](#)
2. <https://lumivero.com/products/nvivo/>

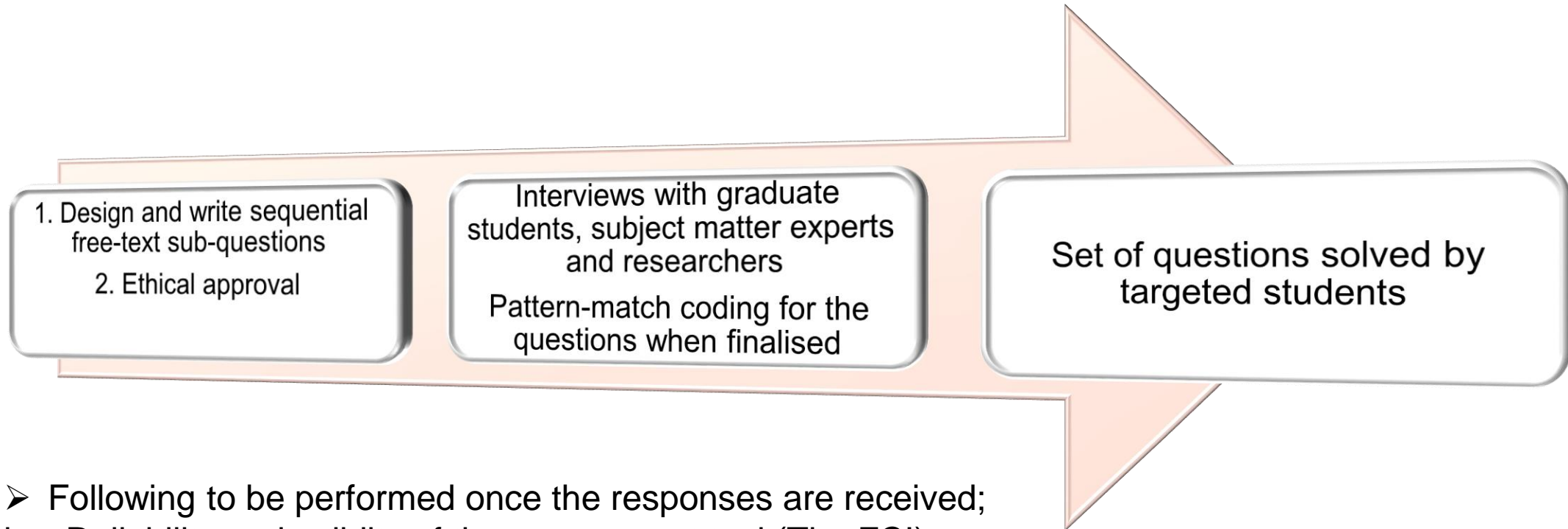


22 wrote that one of the two forces was more than another.

# Free-text Sub-questions



- Free-response version of the Force Concept Inventory are very effective when it comes to probe misconceptions in Newtonian mechanics.
- However, it has been observed that Free-response questions don't eliminate the possibility of guess-work.
- By posing carefully designed sub-questions, we can eliminate the guess work and understand the expertise level of students.



- Following to be performed once the responses are received;
  - i. Reliability and validity of the assessment tool (The FCI)
  - ii. Check for possible gender biasing
  - iii. Possible modification in pattern-match coding based on the responses
  - iv. Factor analysis across the sub-questions
  - v. Thematic and keyword analysis to be done using NVIVO software

1. Hestenes, D. and Halloun, I. (1995). *TPT*, 33(8), pp.502–502
2. Dietz, R.D., Pearson, R.H., Semak, M.R. and Willis, C.W. (2012). *Nucleation and Atmospheric Aerosols*
3. Murshed, M.B. (2020). *International Journal of Psychosocial Rehabilitation*, 24(5), pp.143–151.

Thank you