PhysPort Implementation Guide:
Force Concept Inventory (FCI)

Version 95

PhysPort
Supporting physics teaching with research-based resources

Implementation Guide by Adrian Madsen and Sam McKagan

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Implementation

Purpose of the FCI

To assess students' understanding of the most basic concepts in Newtonian physics using everyday language and common-sense distractors.

Course Level: What kinds of courses is it appropriate for?

Intro college and High school

Content: What does it test?

Mechanics Content knowledge (forces, kinematics)

Timing: How long should I give students to take it?

30 minutes

Example Questions

Sample question from the FCI:

A stone dropped from the roof of a single story building to the surface of the earth:

(A) reaches a maximum speed quite soon after release and then falls at a constant speed thereafter.

(B) speeds up as it falls because the gravitational attraction gets considerably stronger as the stone gets closer to the earth.

(C) speeds up because of an almost constant force of gravity acting upon it.

(D) falls because of the natural tendency of all objects to rest on the surface of the earth.

(E) falls because of the combined effects of the force of gravity pushing it downward and the force of the air pushing it downward.

Access: Where do I get the test?

Get verified as an educator to download the test from physport at www.physport.org/assessments/FCI.

Versions and Variations: Which version of the test should I use?

The latest version of the FCI, released in 1995, is called v95. This version has 30 questions and 'fewer ambiguities and a smaller likelihood of false positives' than the original version (Hake 1998). The original 1992 version has 29 questions (Hestenes et al. 1992). The 1992 version was a revision of an earlier test called the Mechanics Diagnostic Test (MDT) (Halloun & Hestenes 1985).

There are also several variations of the FCI. All of the following variations have the same answer key as v95:

- **The Gender FCI (aka Everyday FCI)** uses the same questions and answer choices as the original FCI, but changes the contexts to make them more "everyday"; or "feminine" (McCullough & Meltzer, 2001; McCullough, 2011).
- **The Animated FCI** takes the original FCI questions and animates the diagrams, so it is given on a computer. (Dancy and Beichner, 2006)
- **The Familiar Context FCI** was adapted from the Gender FCI by Jane Jackson.
- **The Simplified FCI** was adapted from the original FCI by Jane Jackson for ninth grade physics. It was written at a 7th grade reading level and includes more illustrations, but tests for the same concepts.

Another variation is less similar to FCI:

- **The Representational Variant of the FCI** takes nine questions from the original FCI and redesigns them using various representations (such as motion map, vectorial and graphical), yielding 27 multiple-choice questions concerning Newton's first, second, and third laws, and gravitation. (Nieminen 2010)

Administering: How do I give the test?

- Give it as both a pre- and post-test. This measures student learning.
  - Give the pre-test before you cover relevant course material.
  - Give the post-test at the end of the term.
- Use the whole test, with the original wording and question order. This makes comparisons with other classes meaningful.
- Make the test required, and give credit for completing the test (but not correctness). This ensures maximum participation from your students.
- Tell your students that the test is designed to evaluate the course (not them), and that knowing how they think will help you teach better. Tell them that correctness will not affect their grades (only participation). This helps alleviate student anxiety.
- Refer to the test by a generic title like "Mechanics Survey" to prevent students from looking up the answers.
- For more details, read the **PhysPort Guides** on implementation:
  - **PhysPort Expert Recommendation on Best Practices for Administering Concept Inventories** (www.physport.org/expert/AdministeringConceptInventories/)

Scoring: How do I calculate my students' scores?

- Download the answer key from PhysPort (www.physport.org/key/FCI)
- Each student's score is their percentage correct out of 30 questions.
- See the **PhysPort Expert Recommendation on Best Practices for Administering Concept Inventories** for instructions on calculating normalized gain and effect size (www.physport.org/expert/AdministeringConceptInventories/)
- Use the **PhysPort Assessment Data Explorer** for analysis and visualization of your students' responses (www.physport.org/explore/FCI)

Clusters: Does this test include clusters of questions by topic?

In the original publication about the FCI (Hestenes et al., 1992) Newtonian concepts in the inventory are outlined for the original version of the test (1992 version). The clusters below correspond to this original categorization, but are for the most recent version (1995 version).

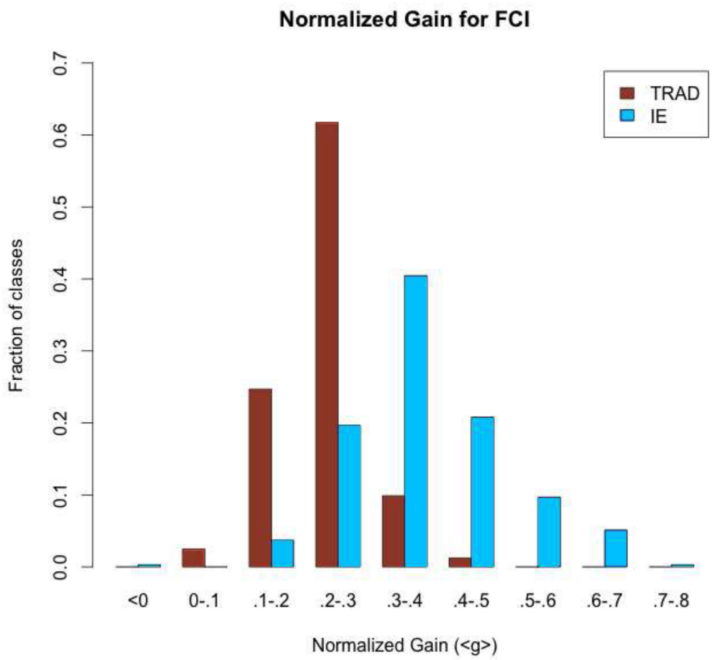
Cluster	Questions
First Law	6, 7, 8,10, 11, 17, 23, 24, 25
Second Law	8, 9, 21, 22, 26
Third Law	4,15,16, 28
Kinematics	9, 12, 14, 19, 20, 21, 22
Superposition	8, 9, 11, 17, 25
Kinds of Forces	1, 2, 3, 5, 11, 12, 13, 14, 17, 18, 27, 29, 30

Typical Results: What scores are usually achieved?

Typical results from Von Korff et al. 2016:

The figure below presents typical FCI normalized gains for two different teaching method types, interactive engagement and traditional lecture, for US and Canadian college students at a wide variety of institution and class types. Courses taught using interactive engagement methods have higher normalized gains than those taught using traditional lecture. These results are from a metaanalysis of FCI gains for 31,000 students in 450 classes, published in 63 papers. The FCI has also been given to tens of thousands of students in high school and outside of the US, who are not included in this study.

The average normalized gain is 0.39 for interactive engagement and 0.22 for traditional lecture.



Interpretation: How do I interpret my students' score in light of typical results?

Look at your your pre-test scores:

FCI pre-test scores tell you a lot about your students' initial ideas about force and motion so that you can adjust your teaching based on the knowledge your students start your course with. You can look at their pre-test scores by cluster to get a better sense of what concepts your students need more help with.

Look at the effect size of the change:

Look at the effect size of the change between your pre- and post-test. This tells you how substantially your pre- and post-test scores differ. Compare your effect size to the ranges given below to find out how substantial the change from pre- to post-test was. For more details, read the **PhysPort Expert Recommendation on Effect Size** (www.physport.org/expert/effectsize)

Effect Size	Cohen's d
Large	~0.8
Medium	~0.5
Small	0.2-0.3

Compare your normalized gain:

You can compare your students' normalized gains on the FCI to those displayed under Typical Results to get a sense of what kinds of gains are possible in different kinds of courses. For more details, read the **PhysPort Expert Recommendation on Normalized Gain (www.physport.org/expert/gain)**

Look at question clusters:

You can also look at the post-test scores for individual questions and question clusters to learn more about which particular concepts your students did well on and which they need help with. This can help you figure out which parts of your teaching worked well, and which parts you could improve in the future.

Resources

Where can I learn more about this test?

D. Hestenes, M. Wells, and G. Swackhamer, Force concept inventory, Phys. Teach. **30** (3), 141 (1992).

Translations: Where can I find translations of this test in other languages?

You can download translations of this test in the following languages from PhysPort:

- **Arabic** translated by Hisham A. Alhadlaq
- **Chinese** translated by Guo Chenyue (China - simplified), Hsing-Kuo (Taiwan - traditional)
- **Croatian** translated by Maja Planinic, Lana Ivanjek, and Ana Susac
- **Czech** translated by J. Burešová, D. Mandíková, Odborná revize překladu: L. Dvořák, V. Žák, E. Hejnová, J. Králík
- **Dutch** translated by Eddy Carette
- **English**
- **Filipino** translated by Danilo A. Tadeo Jr
- **Finnish** translated by Ismo Koponen and Johanna Jauhiainen
- **French** translated by Nathaniel Lasry (Canada), Bernard Blandin, Research Director, CESI (France)
- **German** translated by Christian Kautz based on a translation of the first version by H. Schecker and J. Gerdes
- **Greek** translated by Constantine Naoum
- **Hebrew** translated by Kobi Shvarzbord
- **Hungarian** translated by Gergely Nádori
- **Icelandic** translated by Ragnheiður Guðmundsdóttir
- **Indonesian** translated by Oleh Syuhendri
- **Italian** translated by Leonardo Colletti
- **Japanese** translated by Ishimoto, Uematsu, Tsukamoto, Nitta and Lang
- **Malay** translated by Jaafar Jantan, Ph.D.
- **Norwegian** translated by Dr. Carl Angell & colleagues at English School Laboratory at University of Oslo
- **Persian** translated by Masoumeh Ghasemi
- **Polish** translated by Andrzej (Andrew) Lewicki, Ph.D.
- **Portuguese** translated by Inês Leitão and Luis Breda (Portugal), Debora Cantergi (Brazil)
- **Russian** translated by Igor Proleiko, modified by Jozef Hanc
- **Slovak** translated by Josef Hanč, J. Tóth
- **Spanish** translated by Enrique Macia-Barber, Maria Victoria Hernandez, and Jose Menendez
- **Swedish** translated by Jonte Bernhard (to access, contact jonbe@itn.liu.se)
- **Thai** translated by Pornrat Wattanakasiwich
- **Turkish** translated by Öğretme, Çiçek, Duran, Günneç, Köksal, Türkay

If you know of a translation that we don't have yet, or if you would like to translate this assessment, please contact us!

Background

Similar Tests

The FCI covers similar content to the FMCE. FCI questions 15 and 16 present the same situation as FMCE questions 35-38, though the questions asked about the situation are different on each test. FCI question 28 is nearly identical to FMCE question 39.

Research: What research has been done to create and validate the test?

Research Validation: Gold Star ★

This is the highest level of research validation, corresponding to all seven of the validation categories below.

- ☑ Based on research into **student thinking**
- ☑ Studied using **student interviews**
- ☑ Studied using **expert review**

- Studied using **appropriate statistical analysis**
- Research conducted **at multiple institutions**
- Research conducted **by multiple research groups**
- **Peer-reviewed publication**

Research Overview

About half of the questions on the FCI come from an earlier test called the Mechanics Diagnostic Test (MDT). Questions on the MDT were developed using students ideas from open-ended responses. These questions were then reviewed by experts, refined through student interviews and given to over 1000 students. Statistical analysis of the reliability of the MDT was conducted and the pre- and post-test were found to be highly reliable. For those FCI questions not taken directly from the MDT, open-ended responses and responses given by students in interviews were compared to ensure the questions were being interpreted correctly. Since its release, over 50 studies have been published using the FCI at both the high school and college level at over 70 institutions and including data on over 35,000 students. Most notable is the study by Hake (1998) comparing FCI scores based on instructional method for over 6500 students.

Developer: Who developed this test?

David Hestenes, Malcolm Wells, Gregg Swackhamer, Ibrahim Halloun, Richard Hake, and Eugene Mosca

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