

# Results on the *Force Concept Inventory* by Adult Learners

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25 years ago a group of adult learners interested in physics formed a discussion group, which is still meeting monthly.<sup>[1]</sup> Participants have a wide variety of backgrounds, from high school science teachers to art dealers. Most either do not have any traditional science background or had taken a traditional physics or other science course many years ago. However, many were enrolled in a non-credit evening course in modern physics without mathematics offered nearly 3 decades ago.<sup>[2]</sup>

The *Force Concept Inventory* (FCI) is one of a growing number of diagnostic instruments that are creating a revolution in Physics curricula around the world. The instruments identify common misconceptions held by high school and beginning university physics students. Curricula are being designed with the explicit goal of clearing up these misconceptions. <sup>[3]</sup>  
<sup>[4]</sup>

Recently I gave the FCI to this group of adult amateurs. 16 people participated. Although a very small sample, the results may nonetheless have some interest.

The mean was **64%**, with a range from 31% to 87%. The standard error of the mean is **4%**.  
<sup>[5]</sup>

The mean is significantly higher (~ 20% - 30%) than pre-tests of beginning Physics students at the high school, college or university level.<sup>[6]</sup> For teenagers, there is some indication that performance on the FCI increases by 3 – 4 % per year and that the increase is due more to life experience than formal instruction.<sup>[7]</sup> Our results are consistent with this increase continuing beyond adolescence.

The participants pointed out a problem with Question 26 of the test. The question is shown in Table 1.

Table 1. Question 26 of the FCI

Question 25 of the test begins with:

**A woman exerts a constant horizontal force on a large box. As a result the box moves across a horizontal floor at a constant speed " $v_0$ ".**

Then Question 26 is:

**If the woman of the previous question doubles the constant horizontal force that she exerts on the box to push it on the same horizontal floor, the box then moves:**

1. **with a constant speed that is double the speed " $v_0$ " in the previous question.**
2. **with a constant speed that is greater than the speed " $v_0$ " in the previous question, but not necessarily twice as great.**
3. **for a while with a speed that is constant and greater than the speed " $v_0$ " in the previous question, then with a speed that increases thereafter.**
4. **for a while with an increasing speed, then with a constant speed thereafter.**
5. **with a continuously increasing speed. (supposedly the correct answer)**

The problem with Question 26 is that if the woman has sufficient strength, speed and stamina, eventually the speed of the box is large enough that the force on the box due to air resistance will match the force she is applying to it. In this case Answer 4 is correct. I believe this question requires re-wording. Great efforts have been made throughout the test to avoid phrases such as "ignore air resistance" so perhaps the setting of this question can be changed to involve a woman astronaut on the airless moon. [8]

Finally, one of the participants, whose first language is not English, had some difficulty in understanding the language used in the test. Re-reading the test and thinking about my many first year university students who also have English as a second (or even third) language, I think that some of our multi-cultural Canadian students may have more difficulty with the language of the FCI than the typical American student.

## Notes

1. D. Harrison and J.D. Prentice, Am. J. Phys **48**, 799 (1980).
2. D. Harrison, Am. J. Phys **47**, 779 (1979).
3. There is a huge literature on Physics Education Research (PER) in general and the

FCI in particular. Googling for *Force Concept Inventory* will return many hits. In print, an excellent introduction to PER is Edward F. Redish, **Teaching Physics with the Physics Suite** (Wiley, 2003), ISBN 0-471-39378-9.

4. The first version of the test was D. Hestenes, M. Wells and G. Swackhammer, *Phys. Teach.* **30**, 141 (1992). We used the test as modified by Halloun, Hake and Mosca in 1995.
5. The standard error of the mean is the standard deviation divided by the square root of the number of tests.
6. R.R. Hake, *Am. J. Phys.* **66**, 64 (1998).
7. A.M Saperstein, *Phys. Teach.* **33**, 138 (1995).
8. In multiple-choice tests, the incorrect answers are called *distractors*. A recent study by Rebello and Zollman looked at the effect of changing distractors, particularly ones using the concept of friction, on student performance on the FCI. N.S Rebello and D.A. Zollman, *Am. J. Phys.* **72**, 116 (2004)

<http://scitation.aip.org/dbt/dbt.jsp?KEY=AJPIAS&Volume=72&Issue=1#MAJOR3>.

One conclusion of their work is that for students with some previous Physics background, including friction in some distractors improves the FCI.

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