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Mental Models: Newton's Second Law

Authors (alphabetical order):
Salomon F. Itza-Ortiz, (sitza@phys.ksu.edu)
N. Sanjay Rebello (srebello@phys.ksu.edu)
Dean Zollman (dzollman@phys.ksu.edu).

Department of Physics, Kansas State University, Manhattan KS, 66506

Contents:

Introduction

The multiple choice surveys (NII model inventories) addressed on this document are preliminary results of research in progress at Kansas State University. The goals of these inventories are:

1. to measure and to trace students' states of understanding of Newton's II Law and changes in those states during instruction.
2. to investigate how students' conceptual understanding is context dependent.

In designing these NII model inventory we addressed three questions:

1. Are the students consistent in their application of models?
2. If not, are students' mental models context dependent?
3. Do particular variables trigger a student's choice of model?

Instructions for the use of the inventory

This inventory has 5 surveys. Their purpose is to trace how a student uses N II law throughout his/her introductory physics course. The five surveys are:

Survey 1: Mechanics: Vertical and Horizontal contexts
A woman pushing a box horizontally (FCI q # 25)
An elevator lifted up (FCI q# 17)

Survey 2: Mechanics: Atwood's machines
To address ideas of horizontal and vertical motion combined.

Survey 3: E&M -- Electric field

A positive charge released in a uniform E field (variation from CSEM q#10)

Survey 4: E&M -- Magnetic field
A positive charge moving in a magnetic field region

Survey 5: E&M -- Induction
Two induction problems from Halliday, Resnick & Walker, 6th Ed.

Observe that only survey I could be used as a pre-post Newton's Second Law diagnostic tool, on its own. All other surveys require instruction on other topics, namely, Atwood's machines, E fields, B fields and induction. Therefore they can be used to trace the use of Newton's Second Law only when these other topics have been introduced. Also observe that the inventories have common variables, namely, mass, speed and force; but also have other variables that depend on the particular context.

Answer key

The options presented in the following table stand for the "Newtonian" model. The other options were created based on answers from students during interviews. They represent other models students use, like the "Aristotelian" model.

Survey/Question	1	2	3	4	5	6
1	b	c	B	a	b	A
2	b	a	B	a	b	A
3	b	a	C	a	b	---
4	d	a	B	b	d	---
5	b	a	A	b	b	B

References

We have presented two papers:

A Summary of Students' Mental Models and Their Applications in Contexts Pertaining to Newton's II Law.
Salomon F. Itza-Ortiz, N. Sanjay Rebello & Dean A. Zollman
Paper presented at the 2002 Physics Education Research Conference, Boise ID.

Students' mental models of Newton's second law: mechanics to electromagnetism
N. Sanjay Rebello, Salomon F. Itza-Ortiz & Dean A. Zollman
Paper presented at the 2003 National Association for Research in Science Teaching (NARST) Conference, Philadelphia, PA.

Our most important references are:

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If you use these inventories or have any comments we would like to hear from you, please send us an email to any of the authors (emails above), thank you.