

TPS for Problem Solving

Dr. Edward Prather

University of Arizona

Center for Astronomy Education (CAE)

<http://astronomy101.jpl.nasa.gov>



Center for Astronomy Education

» Dedicated to the professional development of introductory astronomy instructors

UA-AAU Undergraduate STEM Education Project

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Welcome

Transforming Undergraduate STEM Education

Our Central Goals:

The UA-AAU STEM Education Project seeks to provide thousands of science and engineering majors at the University of Arizona with solid understanding in core STEM disciplines. For this purpose, we are engaged in the redesign of three foundational science courses (general chemistry, introductory biology, and introductory physics/mechanics) and two introductory engineering courses (elements of chemical engineering II and computer programming for engineering applications). The [course redesigns](#) are using student-centered and active learning pedagogy to enhance discipline knowledge and conceptual understanding. Three common themes cut across all redesign efforts: 1) promotion of information and quantitative literacy, 2) use of real-life applications in problem solving, and 3) use of models to develop conceptual understanding. The topics covered in the courses are being critically examined to emphasize core disciplinary ideas, problem-solving abilities, critical thinking, and teamwork, to ensure students are provided with a solid foundational understanding.

News

Coming Soon! STEM Teaching Award

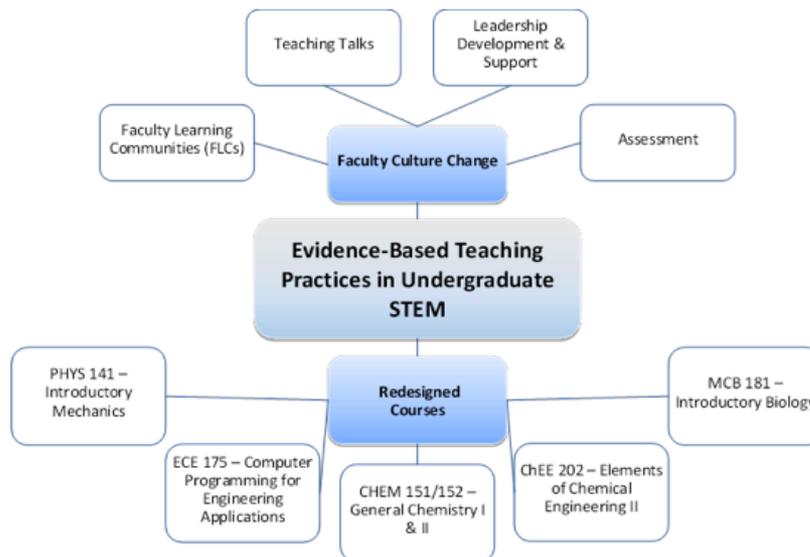
A Call for Nominations for the **Undergraduate STEM Teaching Excellence Award** for Spring, 2015 is Coming Soon!

FLCs Spring 2015

The first meeting of the four FLC groups for Spring 2015 will take place on Wednesday, January 21st.

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Insights from the Univ. of Arizona AAU STEM reform effort in Physics

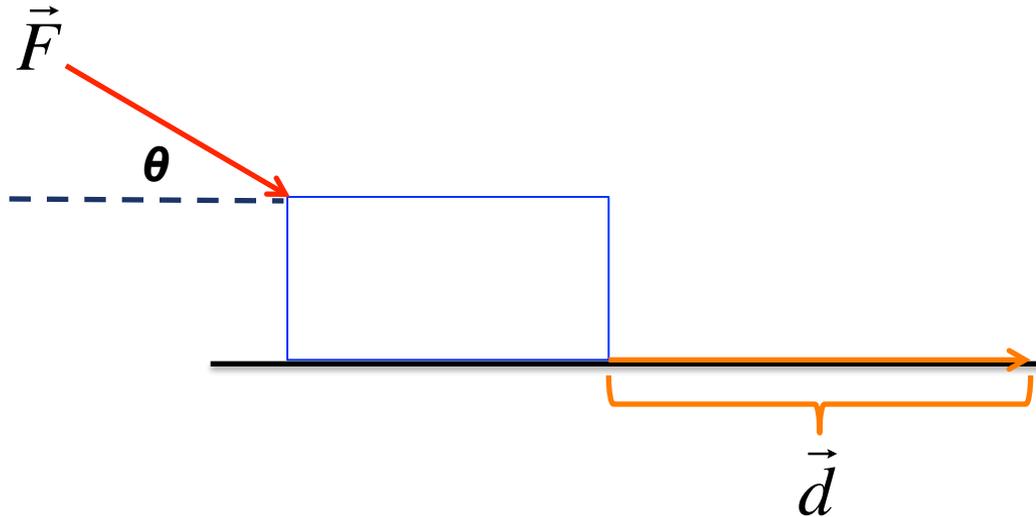
Reformed Class

- Two 50 minute lectures per week
 - Focused on introducing concepts using active engagement instructional strategies and on collaborative group problem solving
 - Minimal derivations of equations
- Each student also attends a 50 minute recitation sections per week
 - Led by graduate TA with assistance from undergraduate peer instructors
 - Students work on collaborative tutorials, which promote reasoning abilities and problem solving skills
- Instructor experienced in astronomy and physics education research, but teaching PHYS 141 for the first time

Traditional Class

- Three 50 minute lectures per week
 - Focused on introducing concepts and on instructor-led modeling of problem solving
 - Many derivations of equations
- Instructor experienced in teaching PHYS 141 and widely regarded by faculty and students as an excellent lecturer

Chapter 6: Work and Kinetic Energy



A constant force \vec{F} is applied to an object. The object has a straight-line displacement \vec{d} .

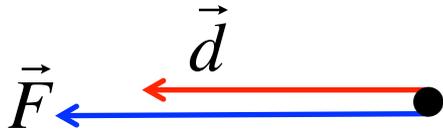
The **work** W by the force on the object is given by

$$W = \vec{F} \cdot \vec{d} = Fd \cos(\theta)$$

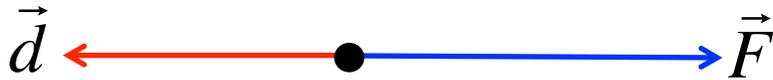
“dot product”
aka “scalar
product”
(see Section 1.10)

SI unit of work: Joules (J)

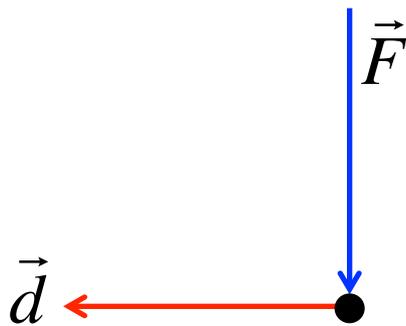
Force and displacement are
vectors, but **work is a scalar**.



When a force (or component of a force) points in the **same direction** as the displacement, the work done by that force is **positive** ($W > 0$).

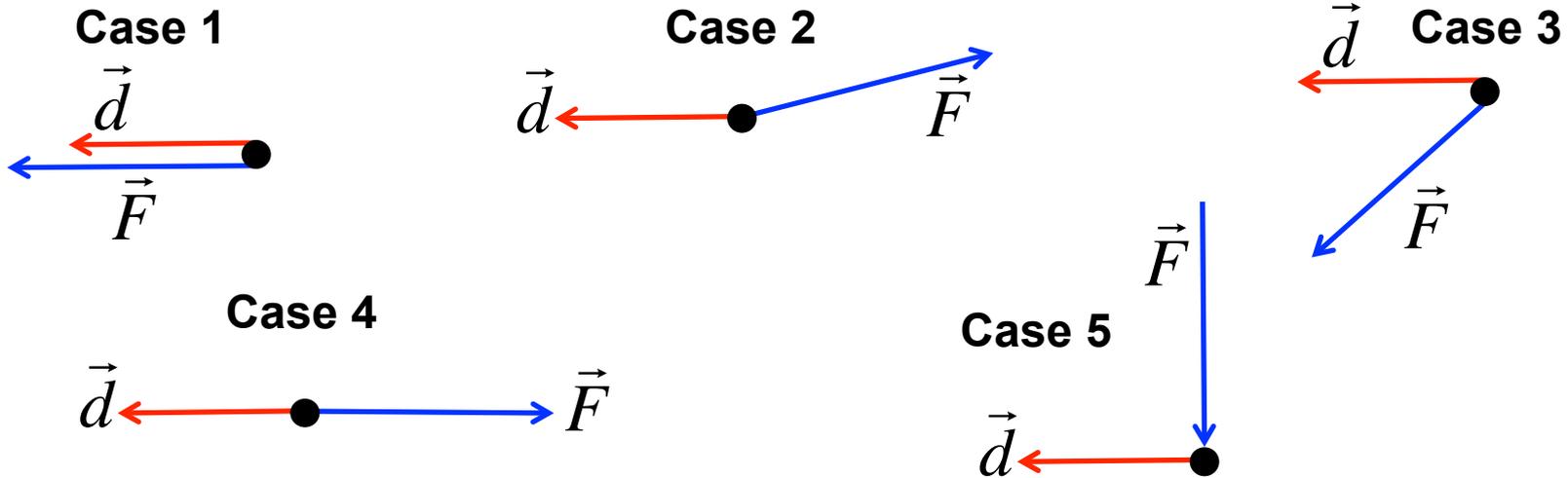


When a force (or component of a force) points in the **opposite direction** as the displacement, the work done by that force is **negative** ($W < 0$).



When a force is **perpendicular** to the displacement, the work done by that force is **zero** ($W = 0$).

In the cases below (1-5), identical particles experience the same displacement. The forces shown acting on the particles all have the same magnitude. Rank each case based on the work done on the particle, from most negative to most positive.

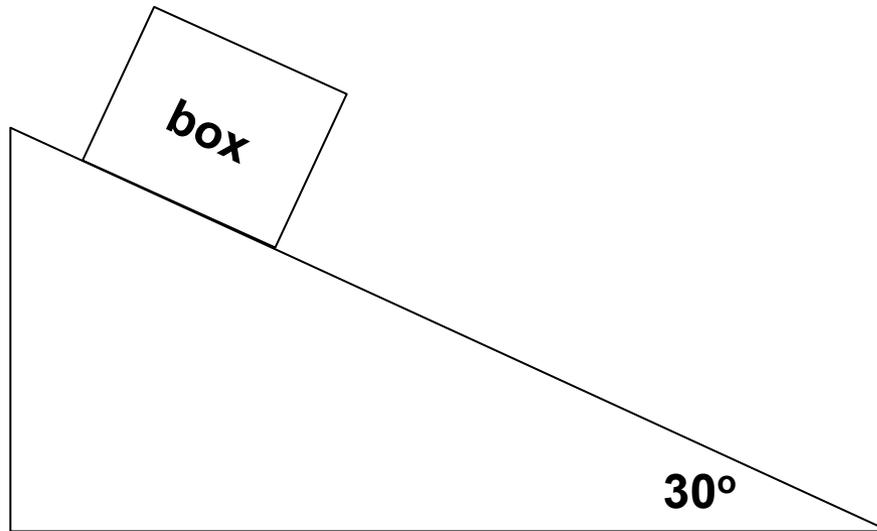


- A) 1, 3, 5, 2, 4
- B) 5, 3, 4, 1, 2
- C) 5, 3, 1, 4, 2
- D) 4, 2, 5, 3, 1
- E) None of the above.

When many forces act on an object, we can calculate the work done on that object by each of those forces.

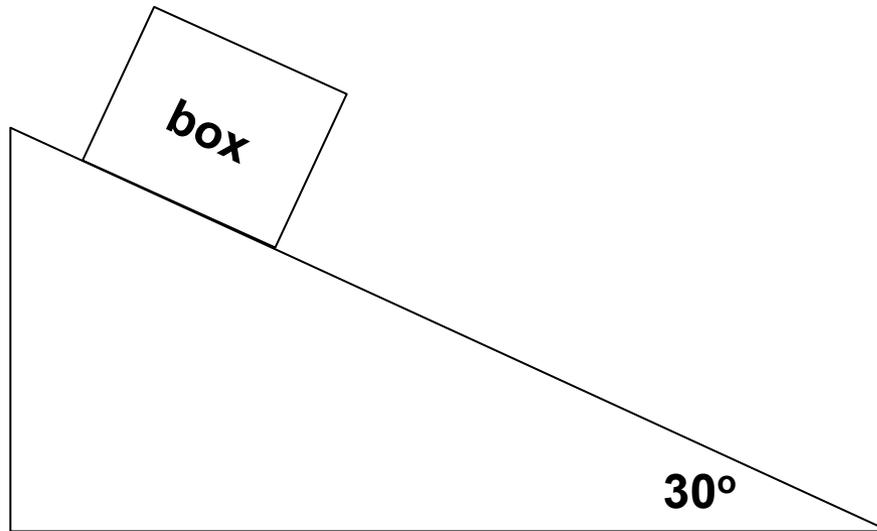
The sum of all of these works is called the **net work** (W_{net}).

A 3.0 kg box starts from rest and slides for 2.0 m down a 30° incline. The coefficient of static friction between the box and the incline is $\mu_k = 0.1$. Find W_{net} .

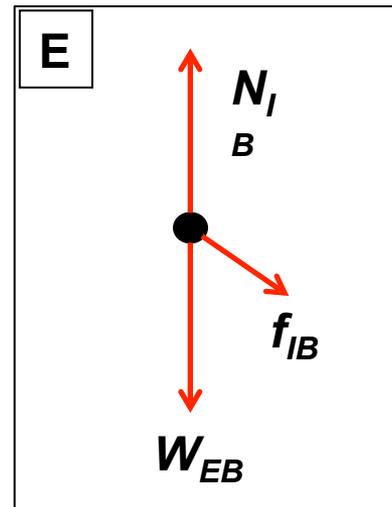
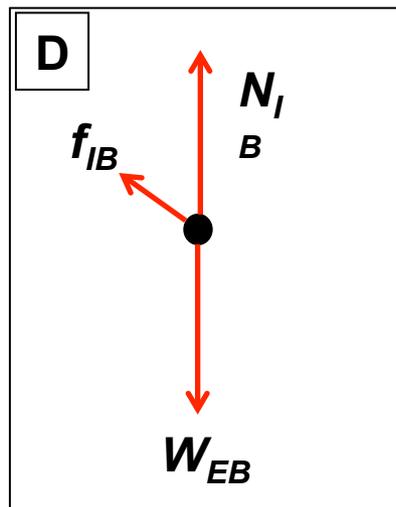
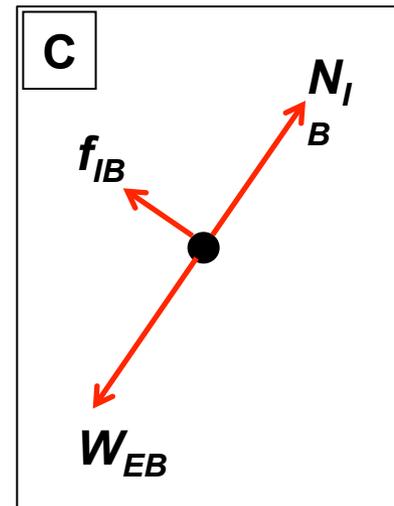
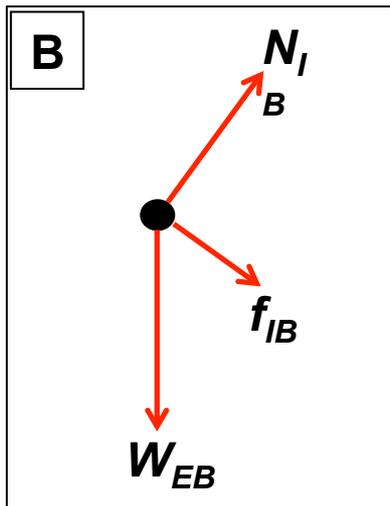
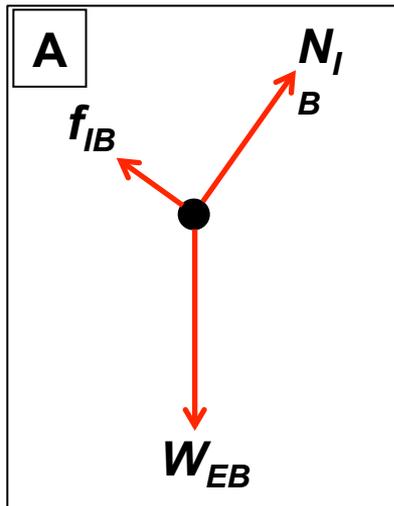


Draw the Free Body Diagram for the Box

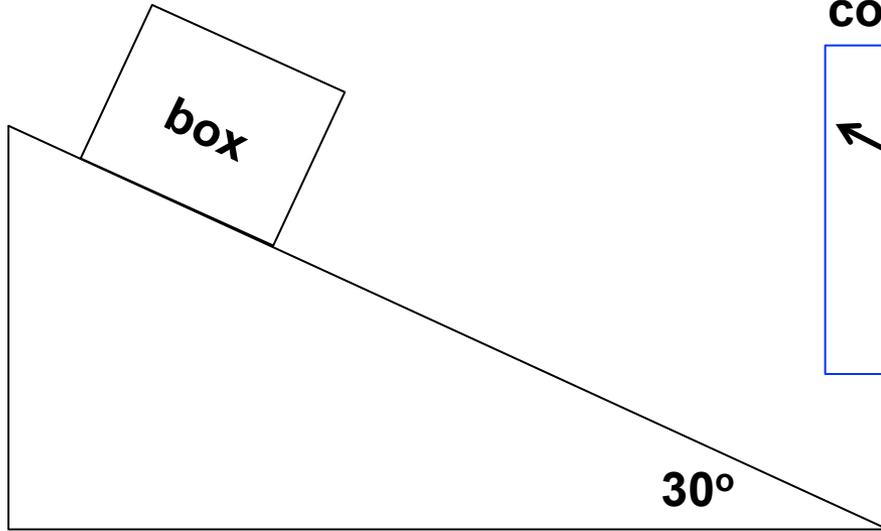
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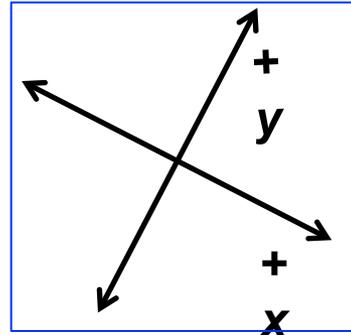
Which of the following is the correct free-body diagram for the box?



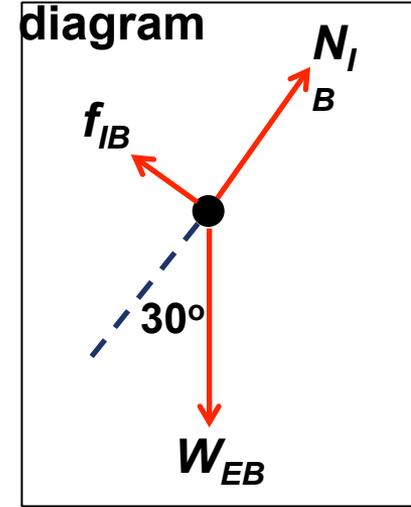
A 3.0 kg box starts from rest and slides for 2.0 m down a 30° incline. The coefficient of static friction between the box and the incline is $\mu_k = 0.1$. Find W_{net} .



coordinate axes



free-body diagram

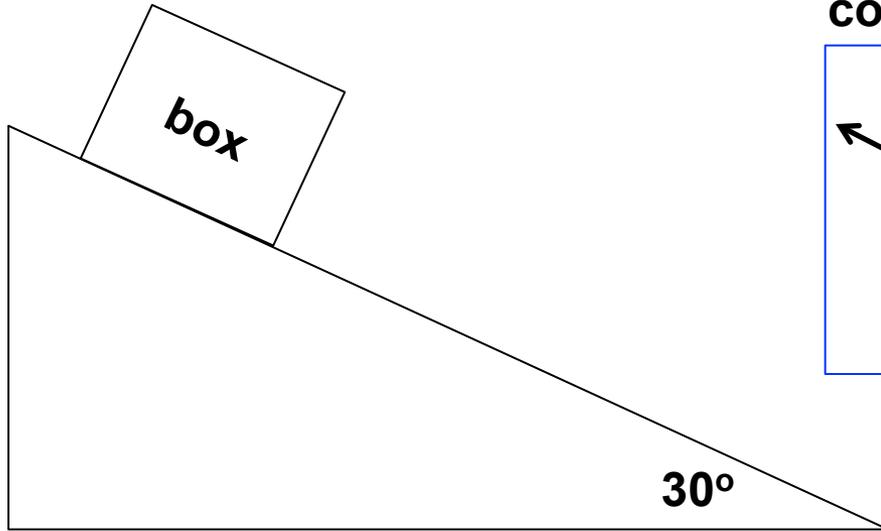


Is the work done by the normal force (W_N) on the box positive, negative, or zero?

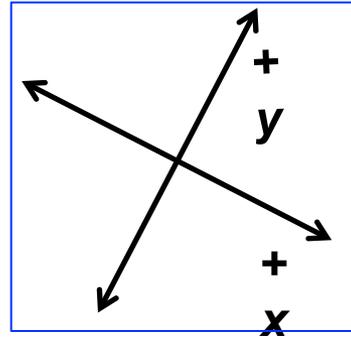
- A) positive
- B) negative
- C) zero

$$W_N = (N_{IB})(d)\cos(90^\circ) = 0 J$$

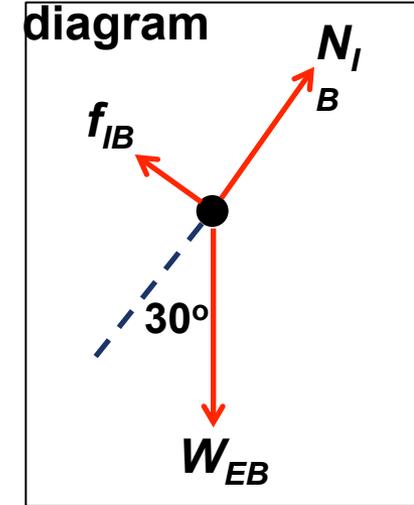
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coordinate axes



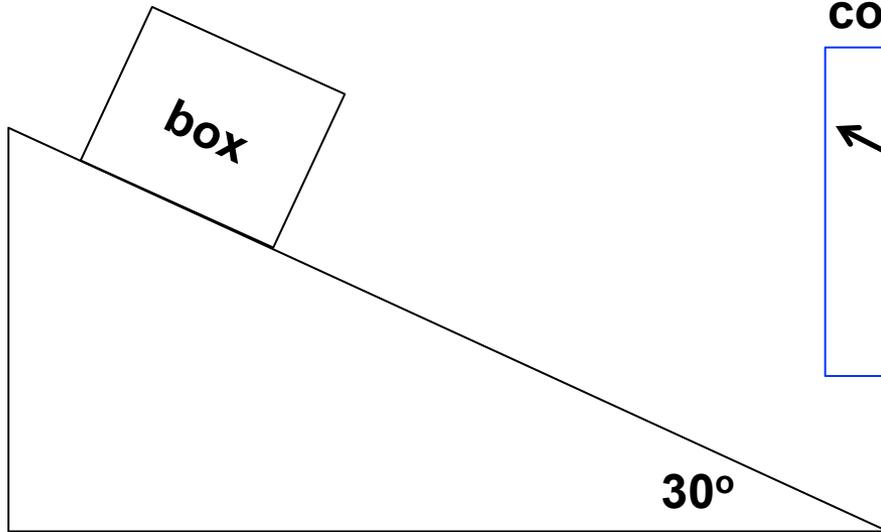
free-body diagram



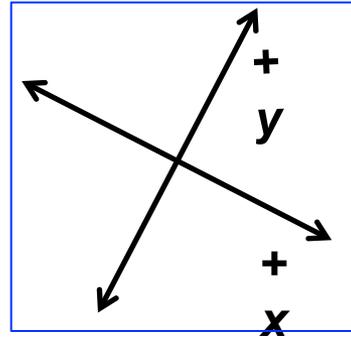
Is the work done by the friction force (W_f) on the box positive, negative, or zero?

- A) positive
- B) negative
- C) zero

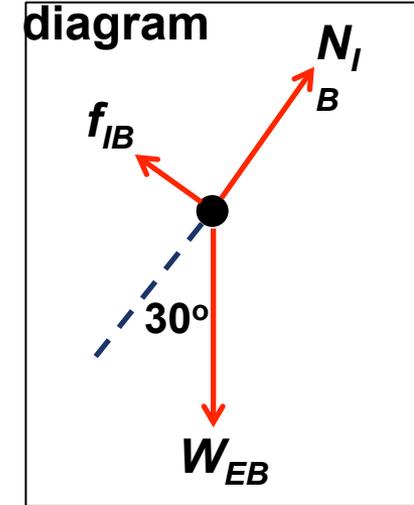
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coordinate axes



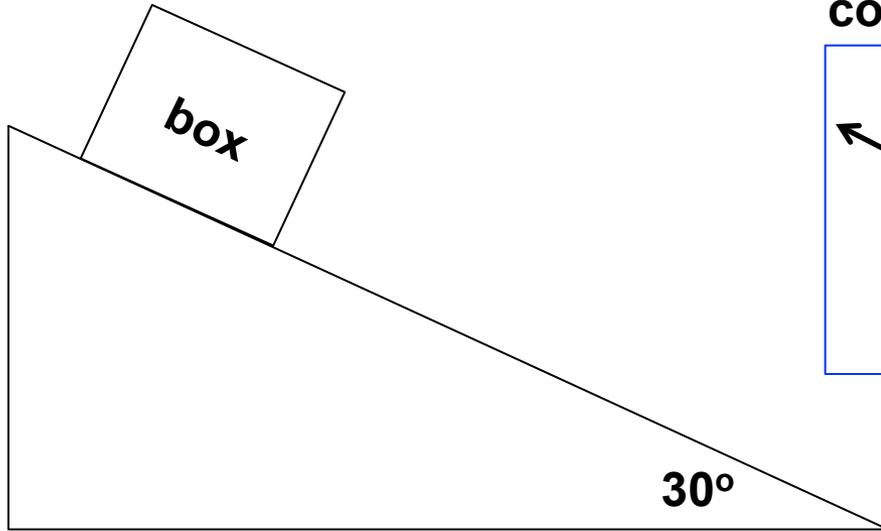
free-body diagram



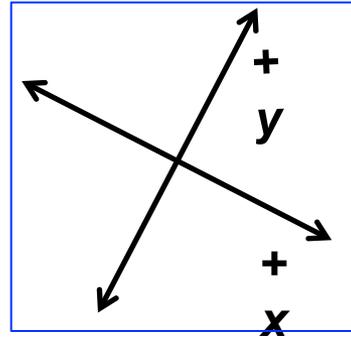
Is the work done by the weight force (W_W) on the box positive, negative, or zero?

- A) positive
- B) negative
- C) zero

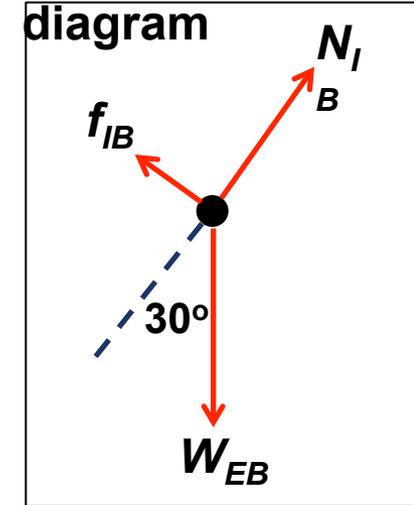
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coordinate axes



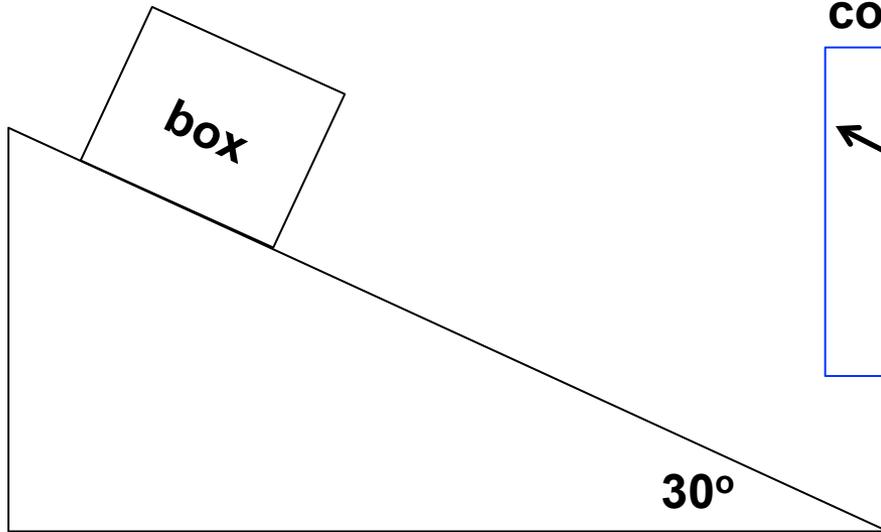
free-body diagram



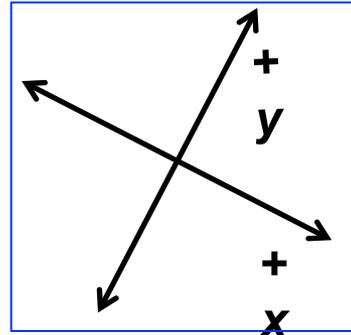
Work done on box by friction force: $W_f = (f_{IB})(d)\cos(180^\circ) = -(f_{IB})(d)$

f_{IB} is given by which of the following?

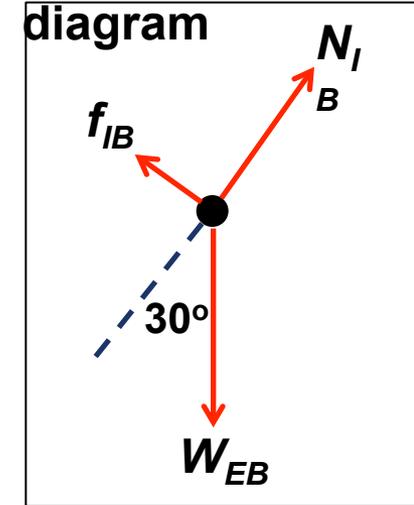
A 3.0 kg box starts from rest and slides for 2.0 m down a 30° incline. The coefficient of static friction between the box and the incline is $\mu_k = 0.1$. Find W_{net} .



coordinate axes



free-body diagram

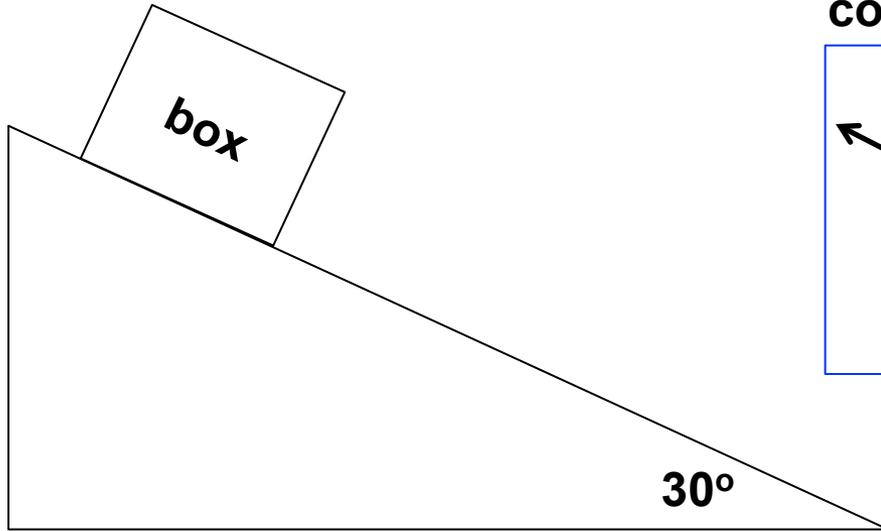


Work done on box by friction force: $W_f = (f_{IB})(d)\cos(180^\circ) = -(f_{IB})(d)$

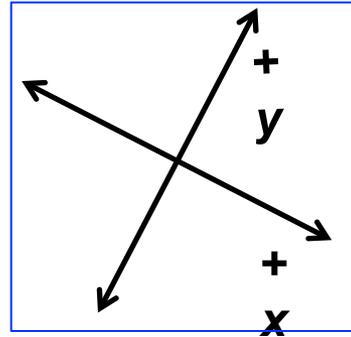
f_{IB} is given by which of the following?

- A) $\mu_k mg \cos(30^\circ)$
- B) $\mu_k mg \sin(30^\circ)$
- C) $\mu_k mg \cos(60^\circ)$
- D) $\mu_k mg$
- E) More than one of the above.

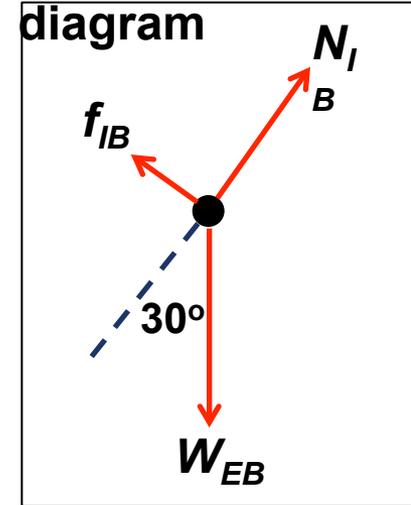
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coordinate axes

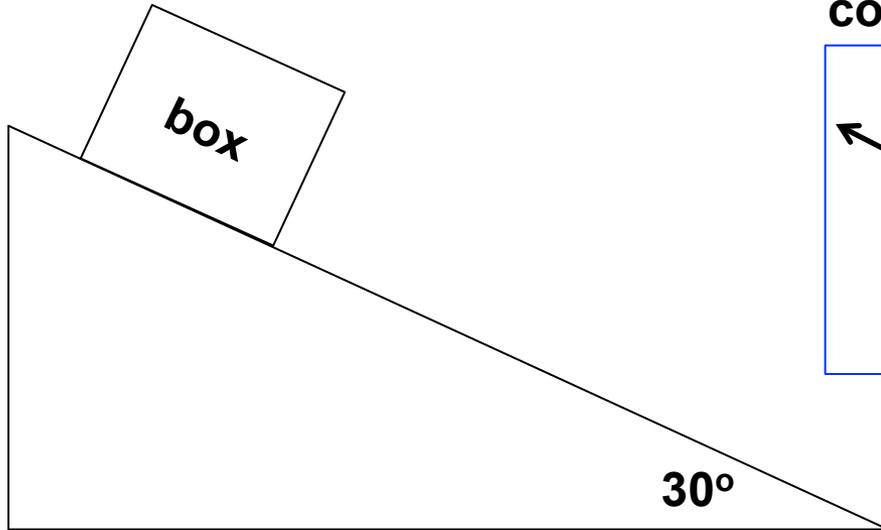


free-body diagram

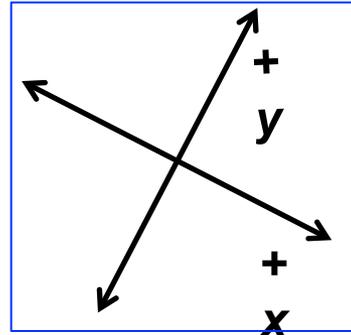


The work done by the weight force (W_W) is given by which of the following?

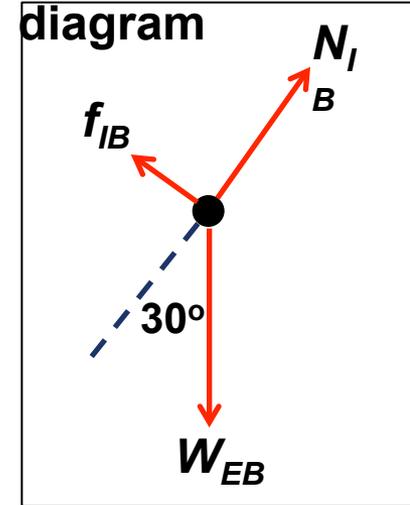
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coordinate axes



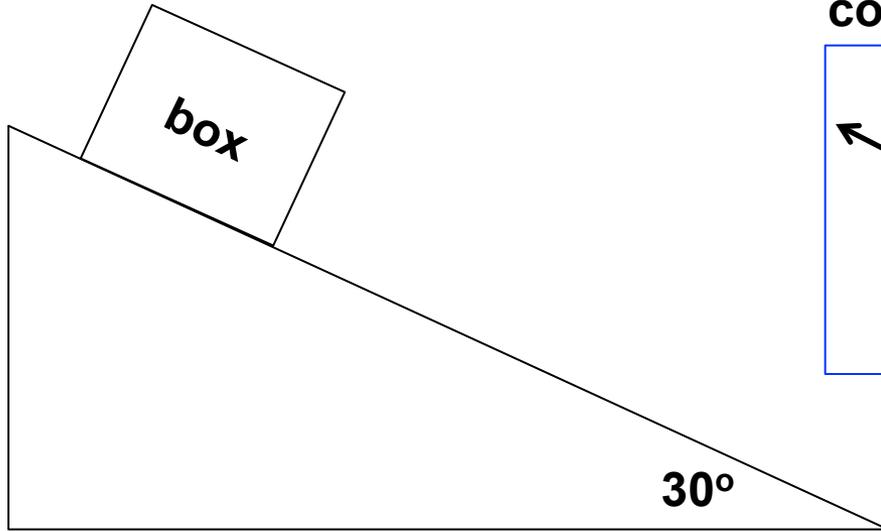
free-body diagram



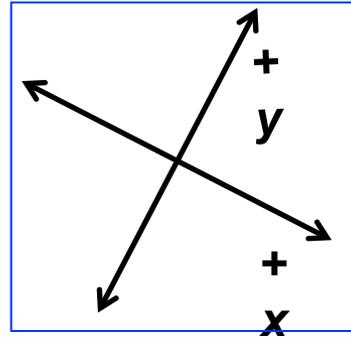
The work done by the weight force (W_W) is given by which of the following?

- A) $mg d$
- B) $mg d \sin (60^\circ)$
- C) $mg d \cos (30^\circ)$
- D) $mg d \cos(60^\circ)$
- E) More than one of the above.

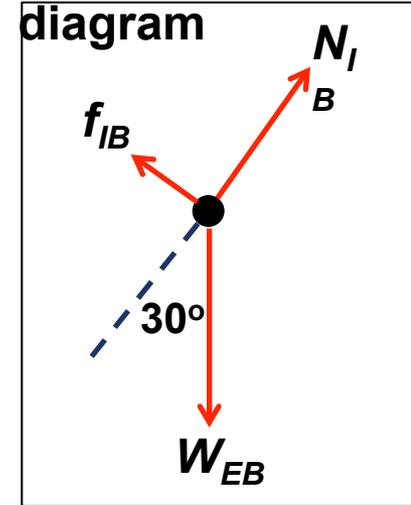
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coordinate axes

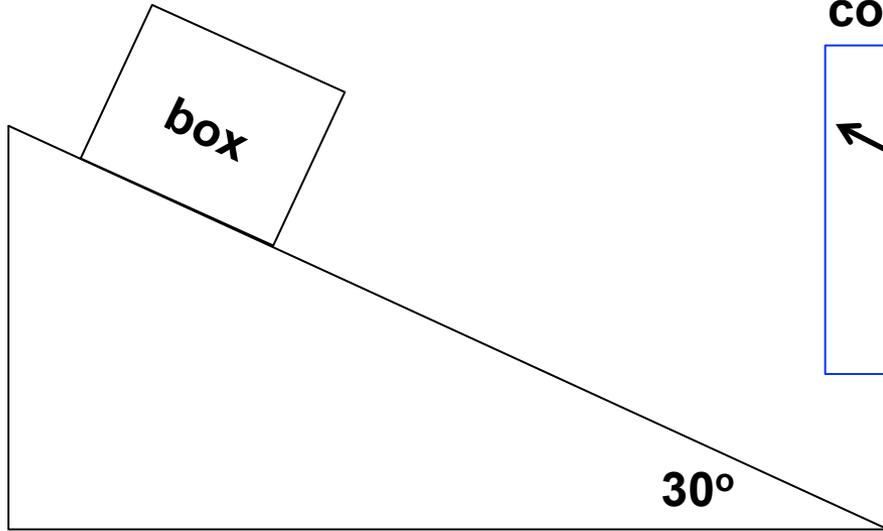


free-body diagram

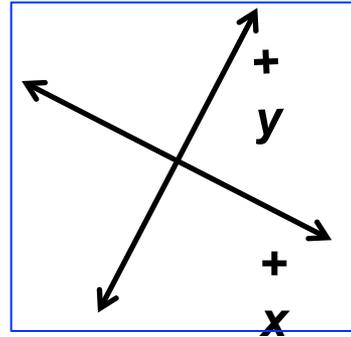


What is the net work (W_{net}) done on the box?

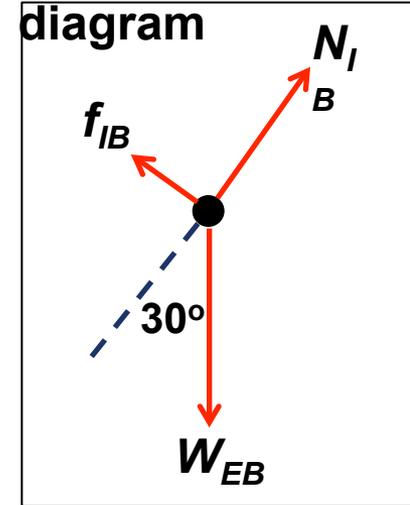
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coordinate axes



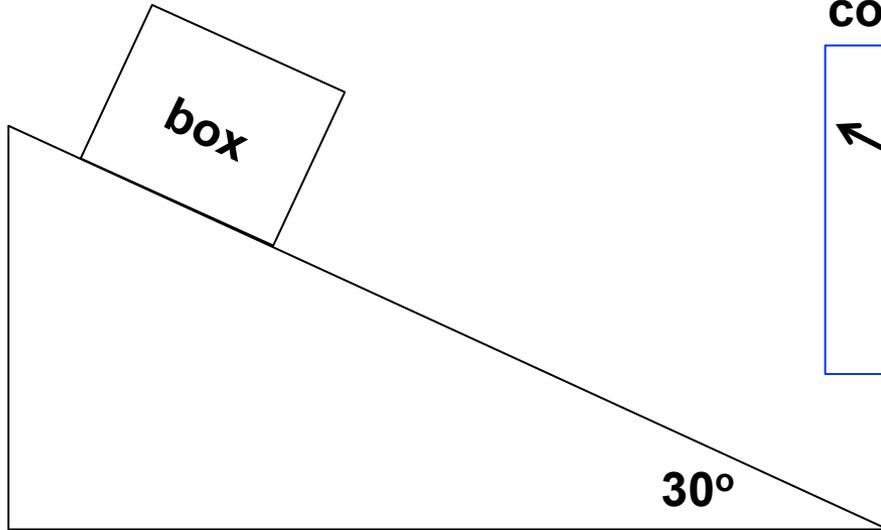
free-body diagram



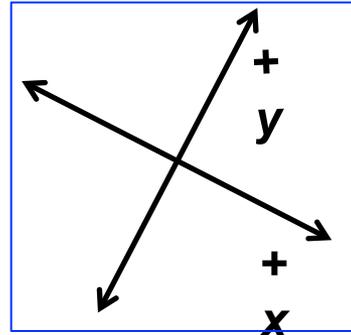
What is the net work (W_{net}) done on the box?

- A) 34.5 J
- B) 29.4 J
- C) 24.3 J
- D) 5.1 J
- E) None of the above.

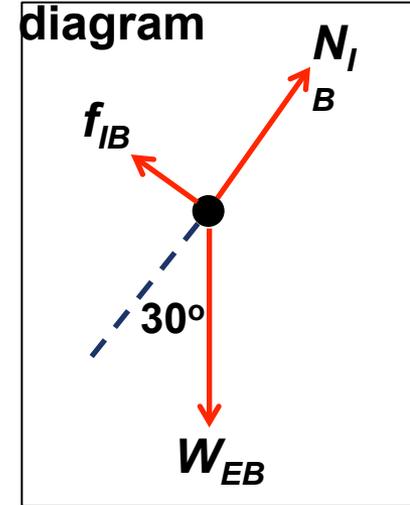
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coordinate axes



free-body diagram



$$W_N = (N_{IB})(d)\cos(90^\circ) = 0 J$$

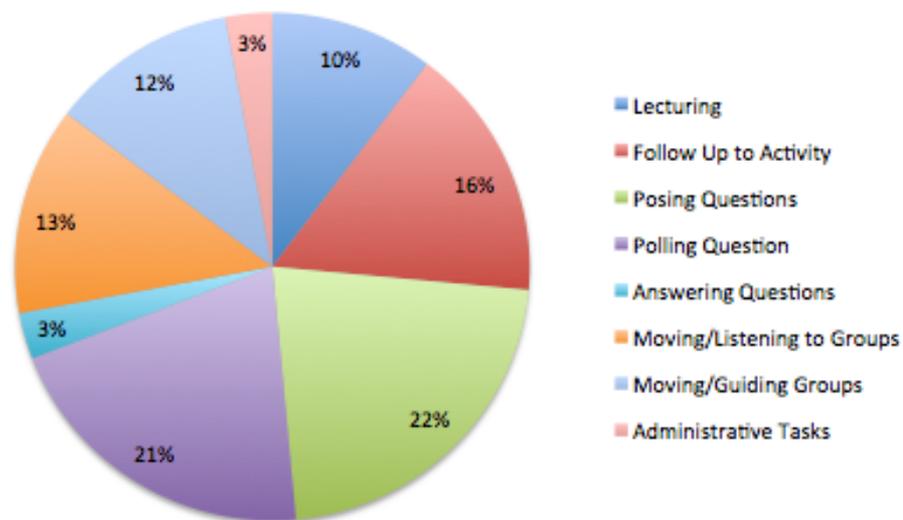
$$W_f = (f_{IB})(d)\cos(180^\circ) = -(\mu_k)(mg \cos(30^\circ))(d) = -5.1 J$$

$$W_W = (W_{EB})(d)\cos(60^\circ) = (mg)(d)\cos(60^\circ) = 29.4 J$$

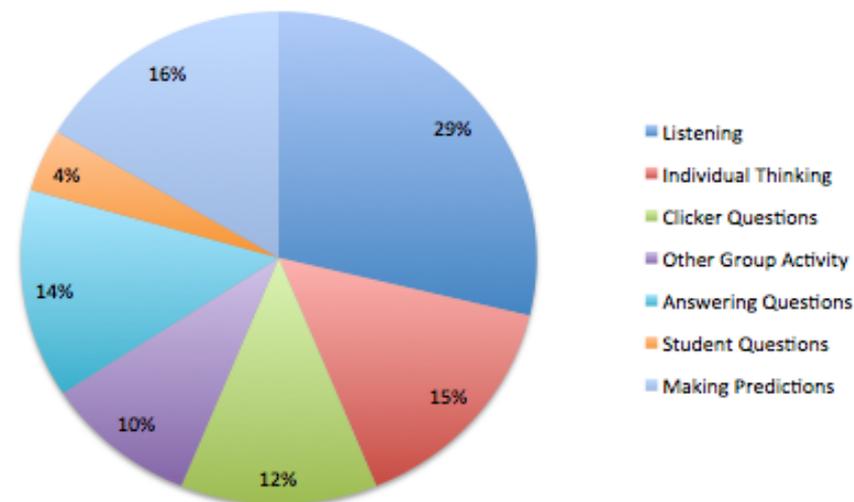
$$W_{net} = W_N + W_f + W_W = 0 J - 5.1 J + 29.4 J = 24.3 J$$

COPUS data from UA Calc-Physics Reformed Course

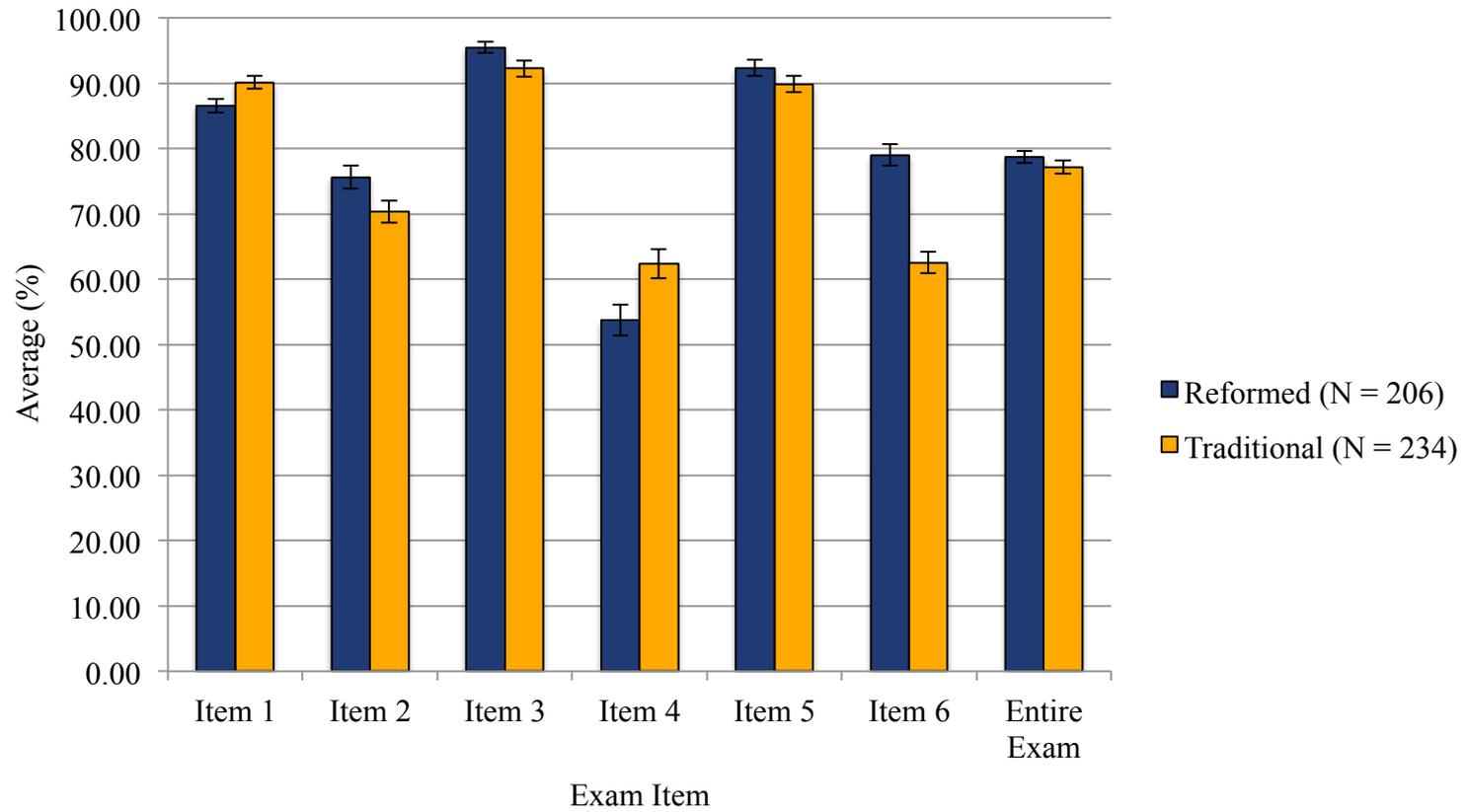
Instructor Doing (50-min. class)



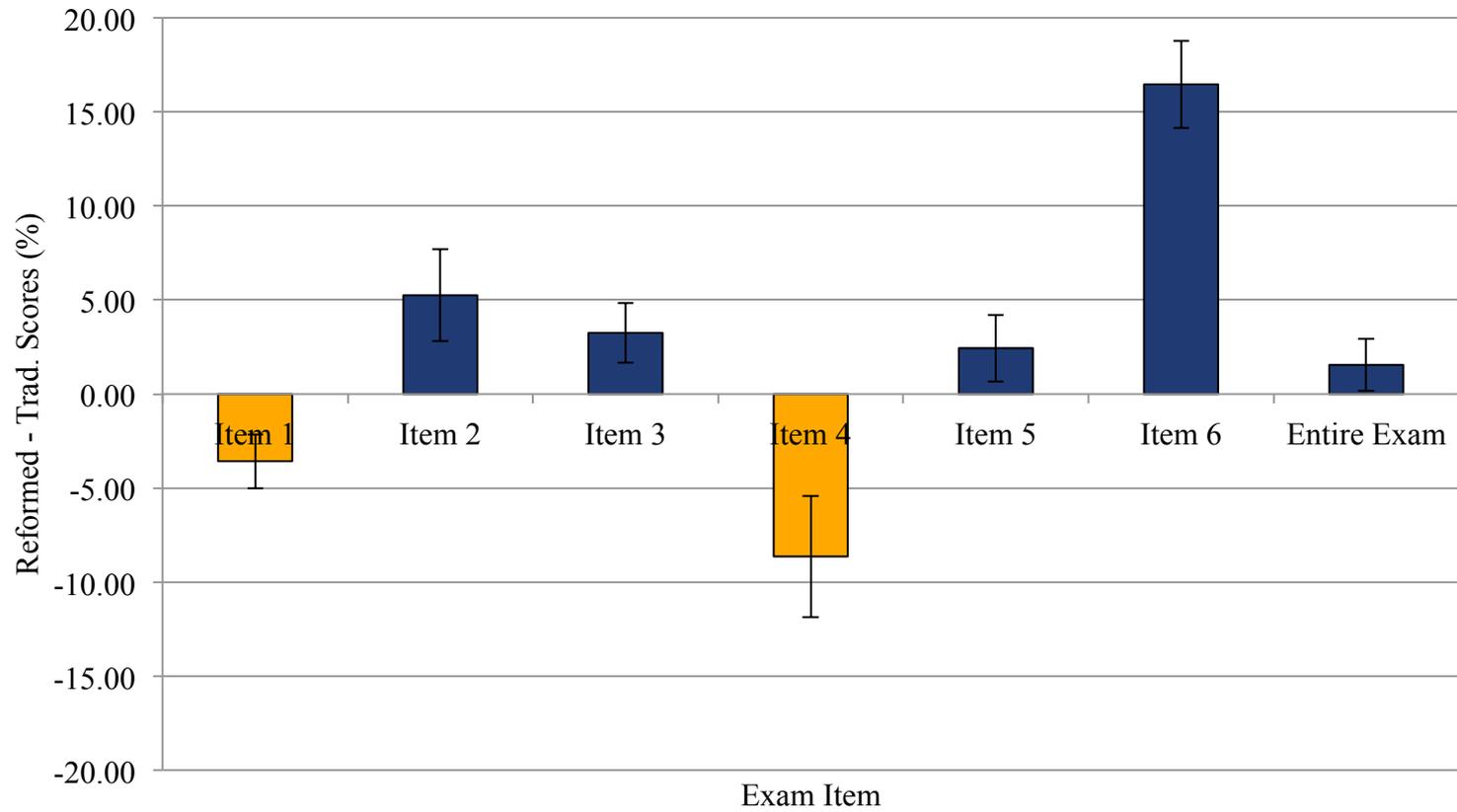
Students Doing (50-min. class)



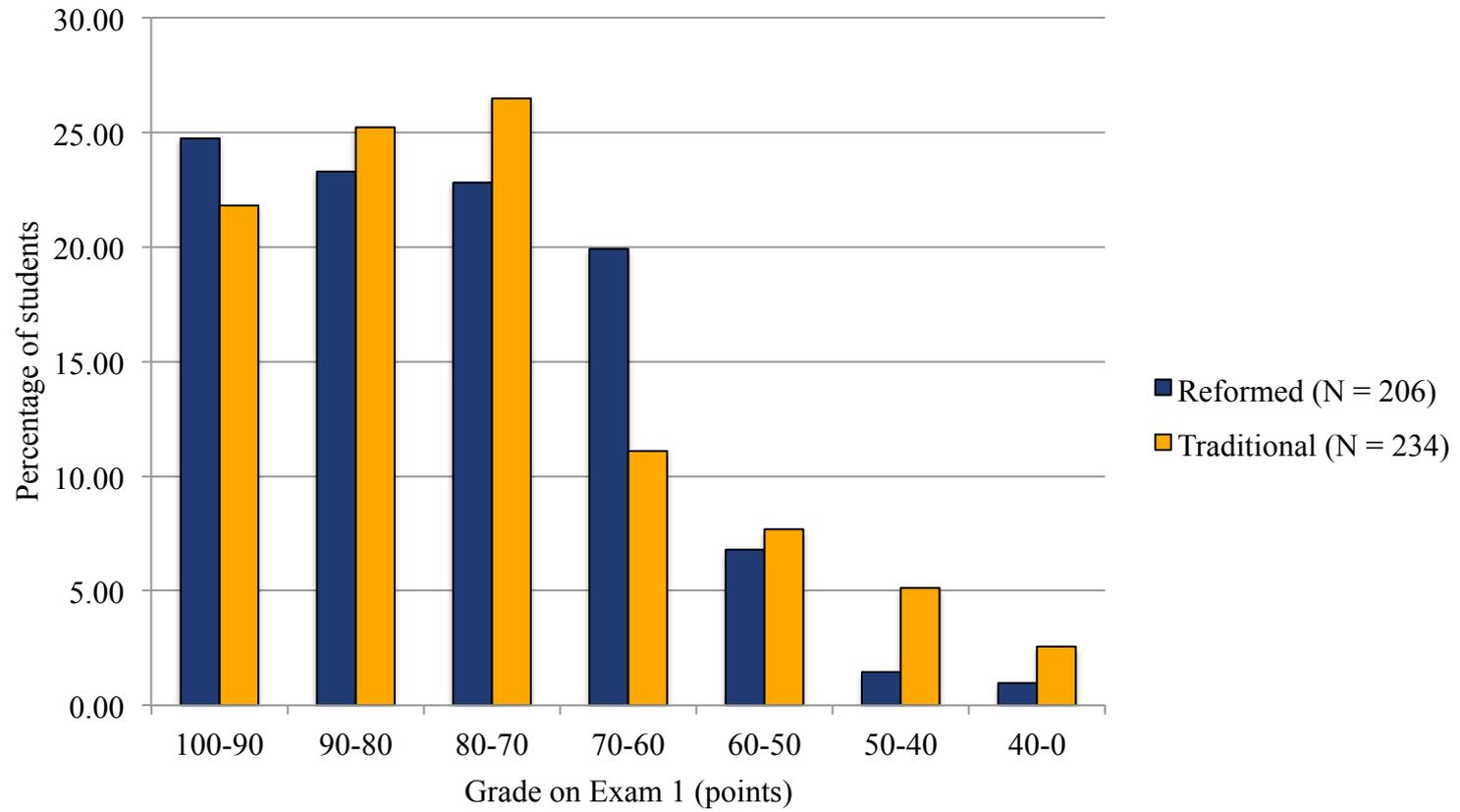
Exam 1



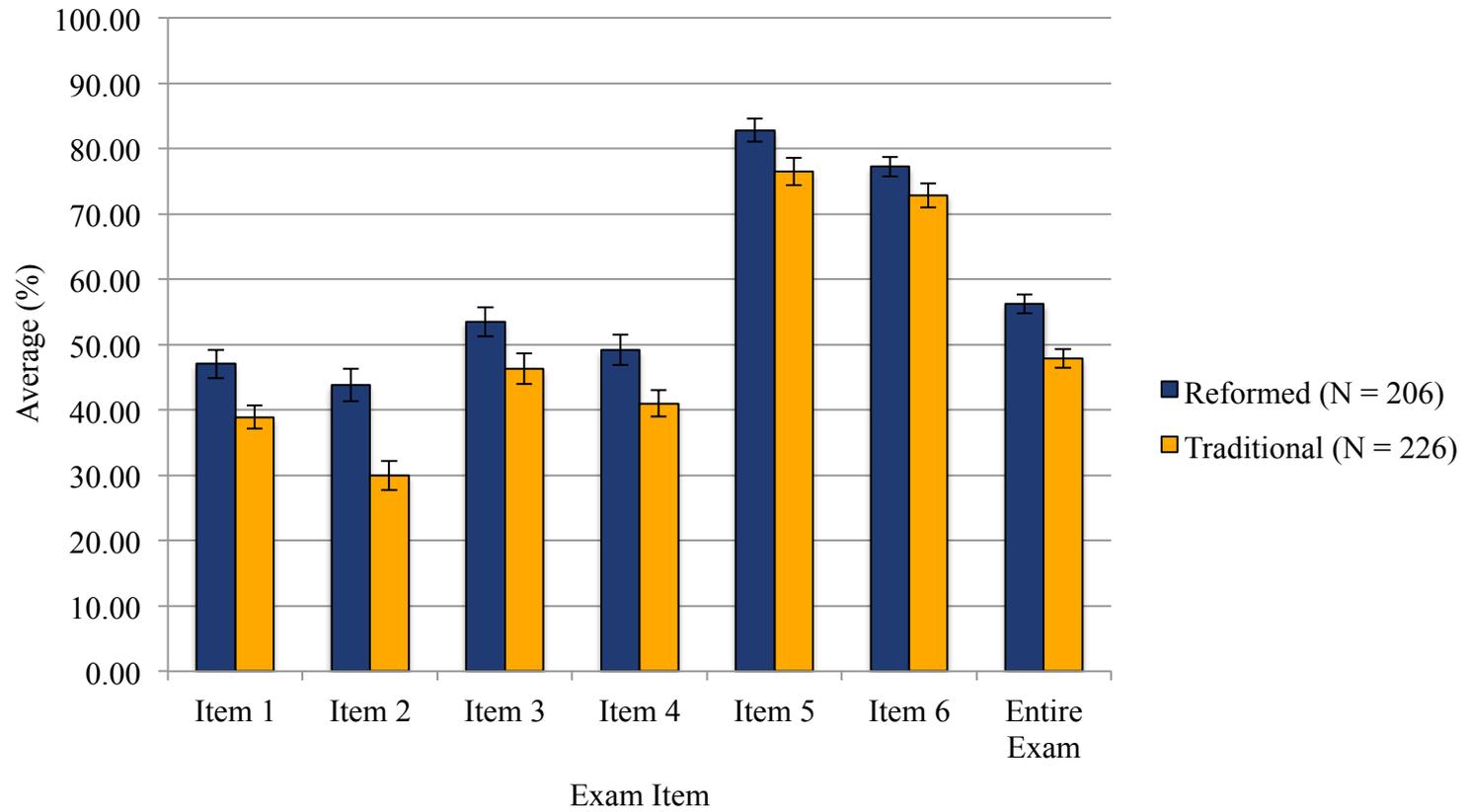
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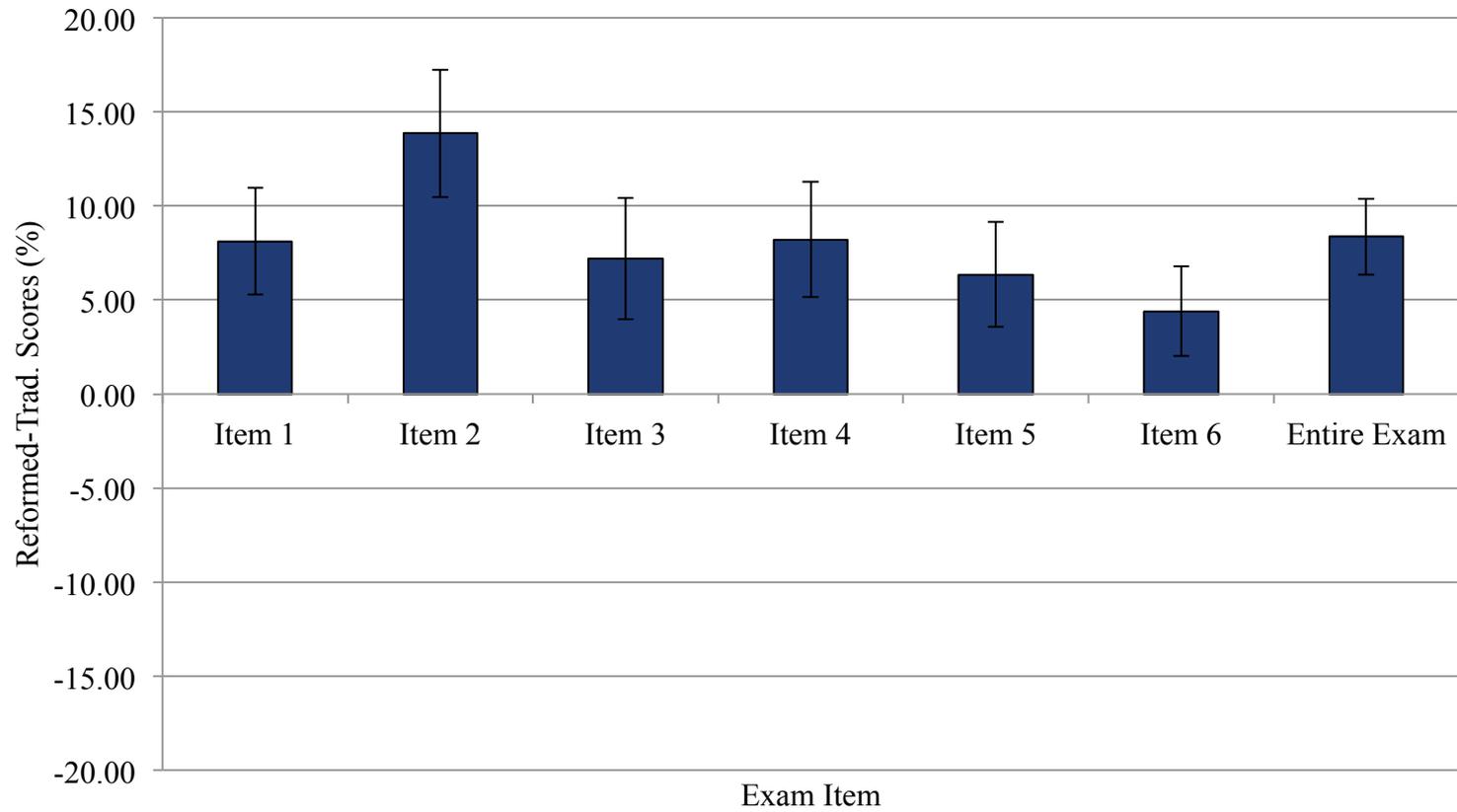
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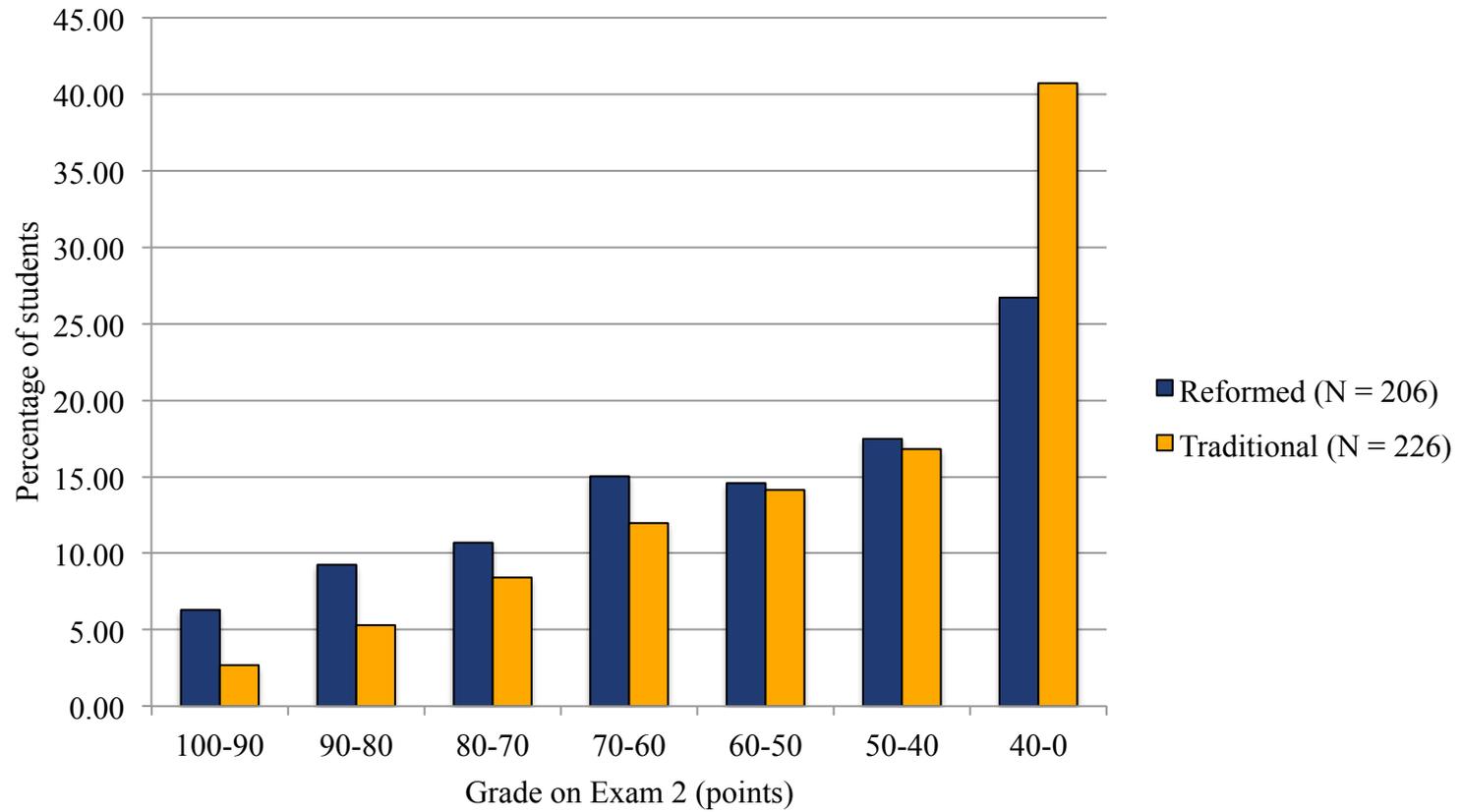
Exam 2



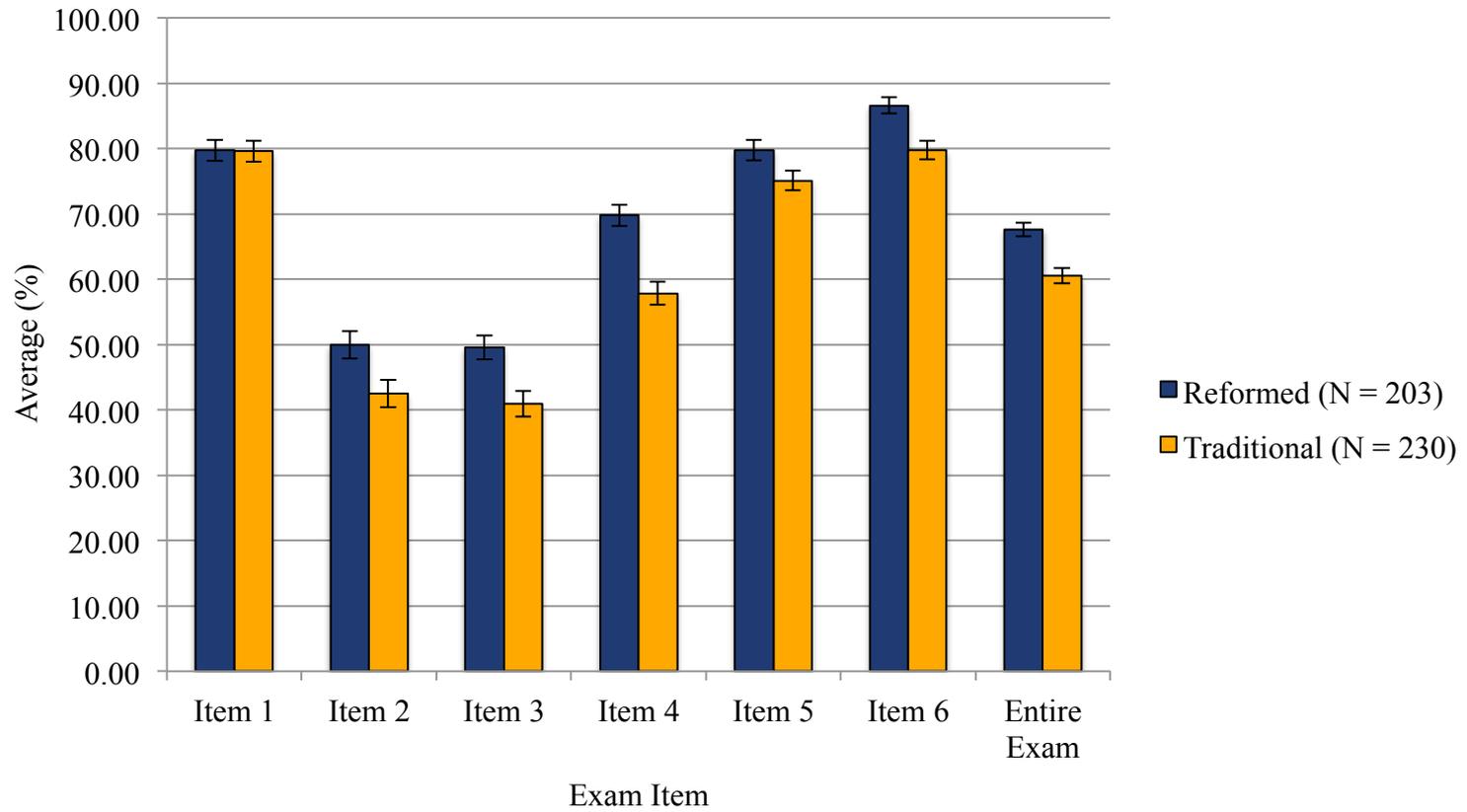
Exam 2



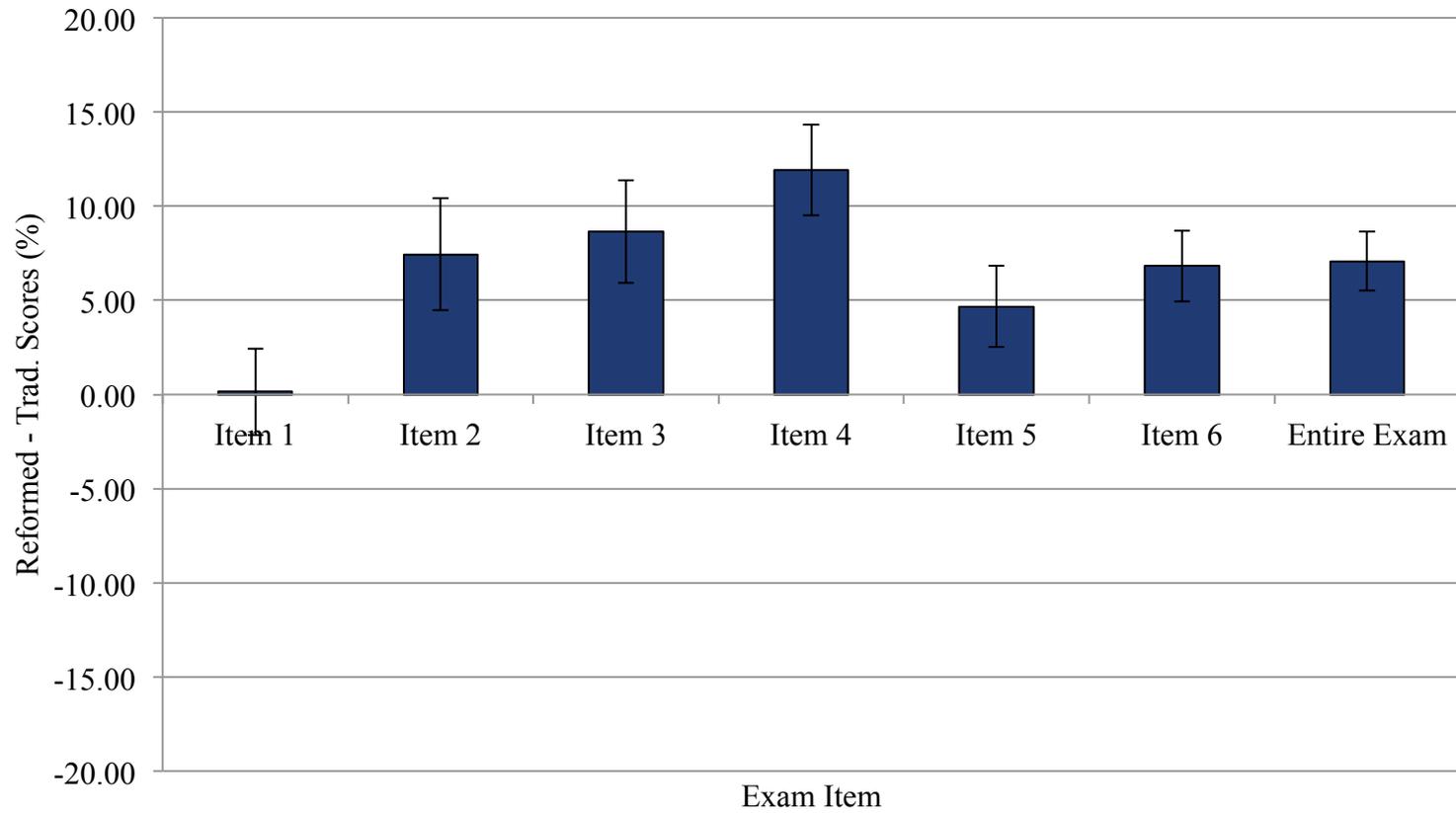
Exam 2



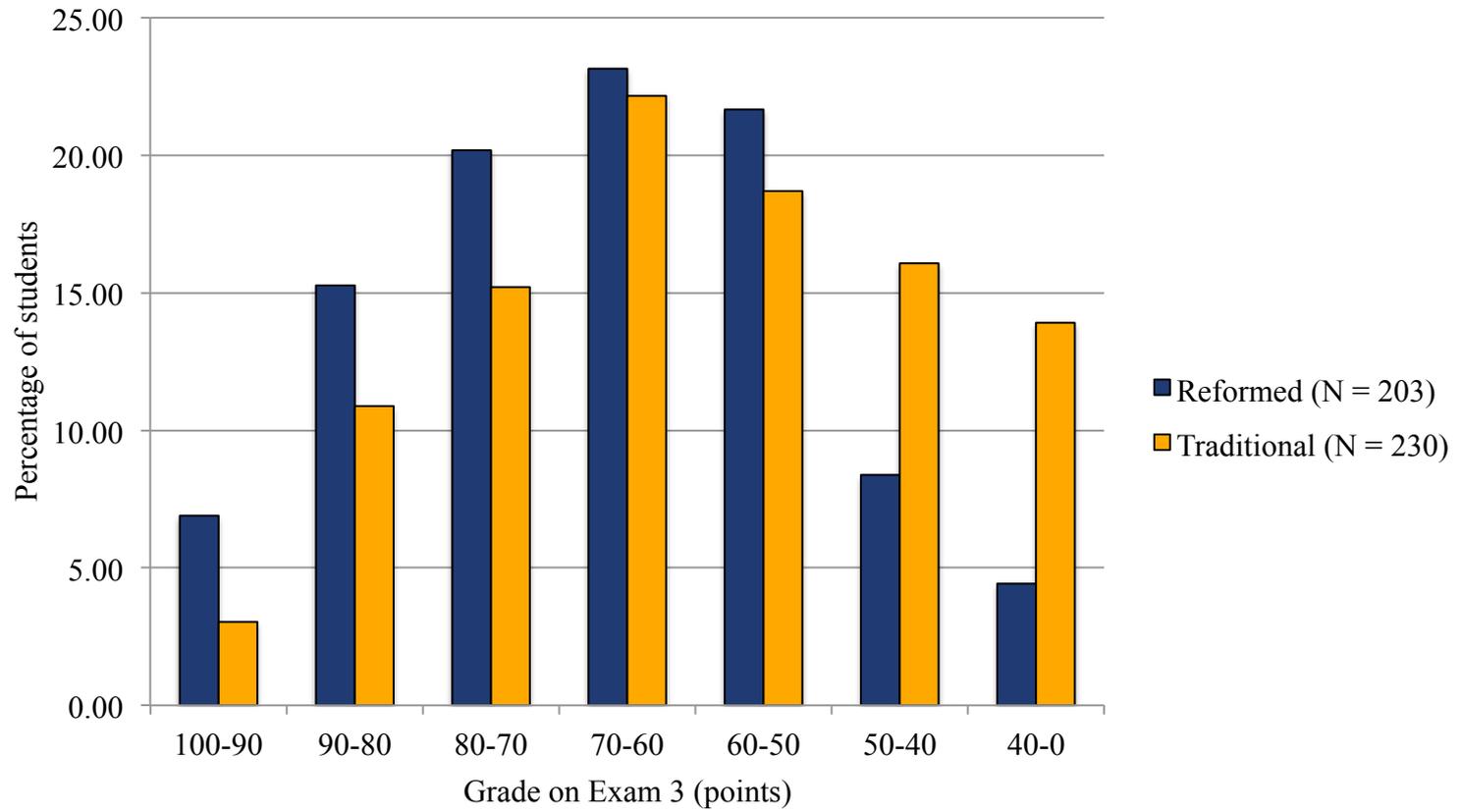
Exam 3



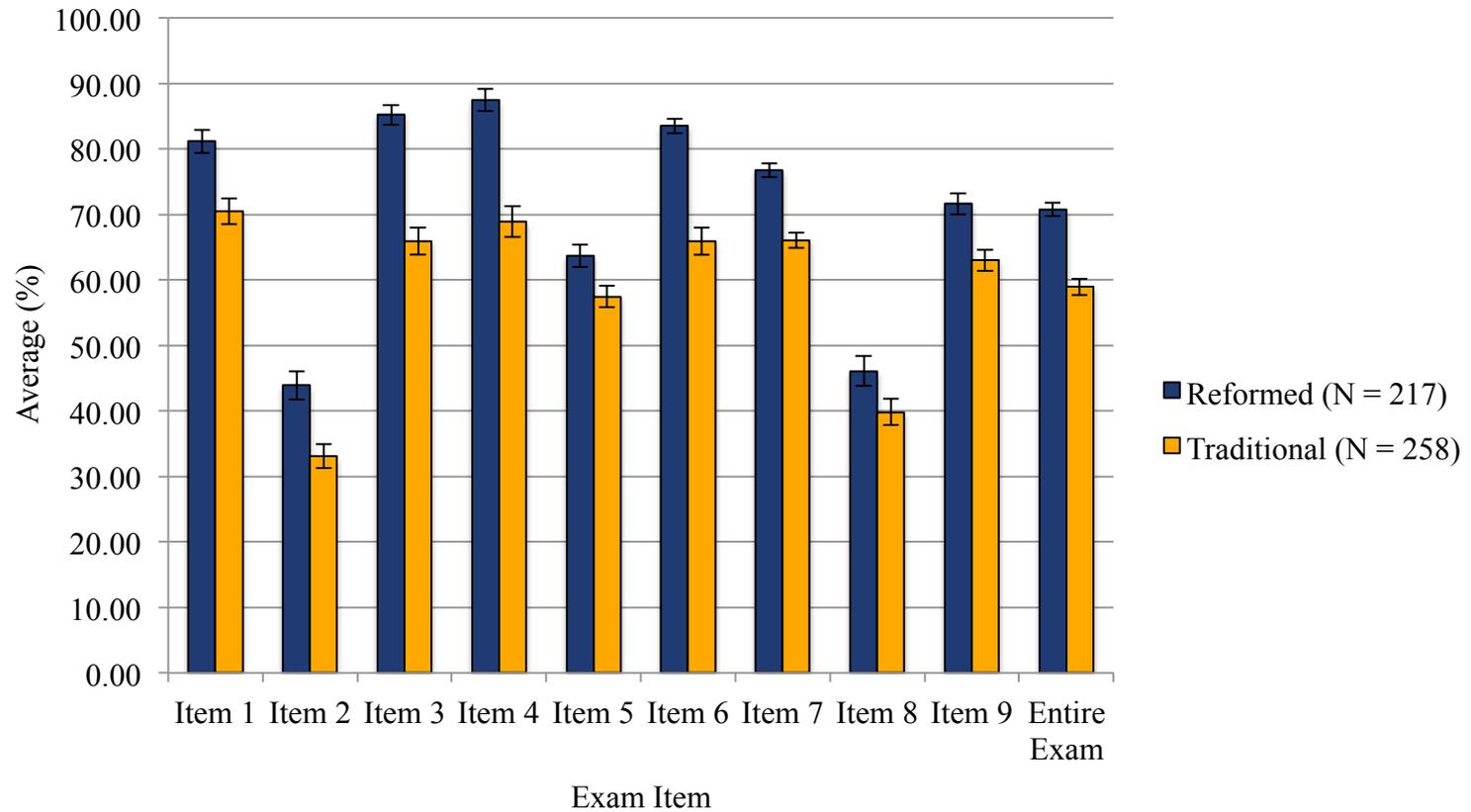
Exam 3



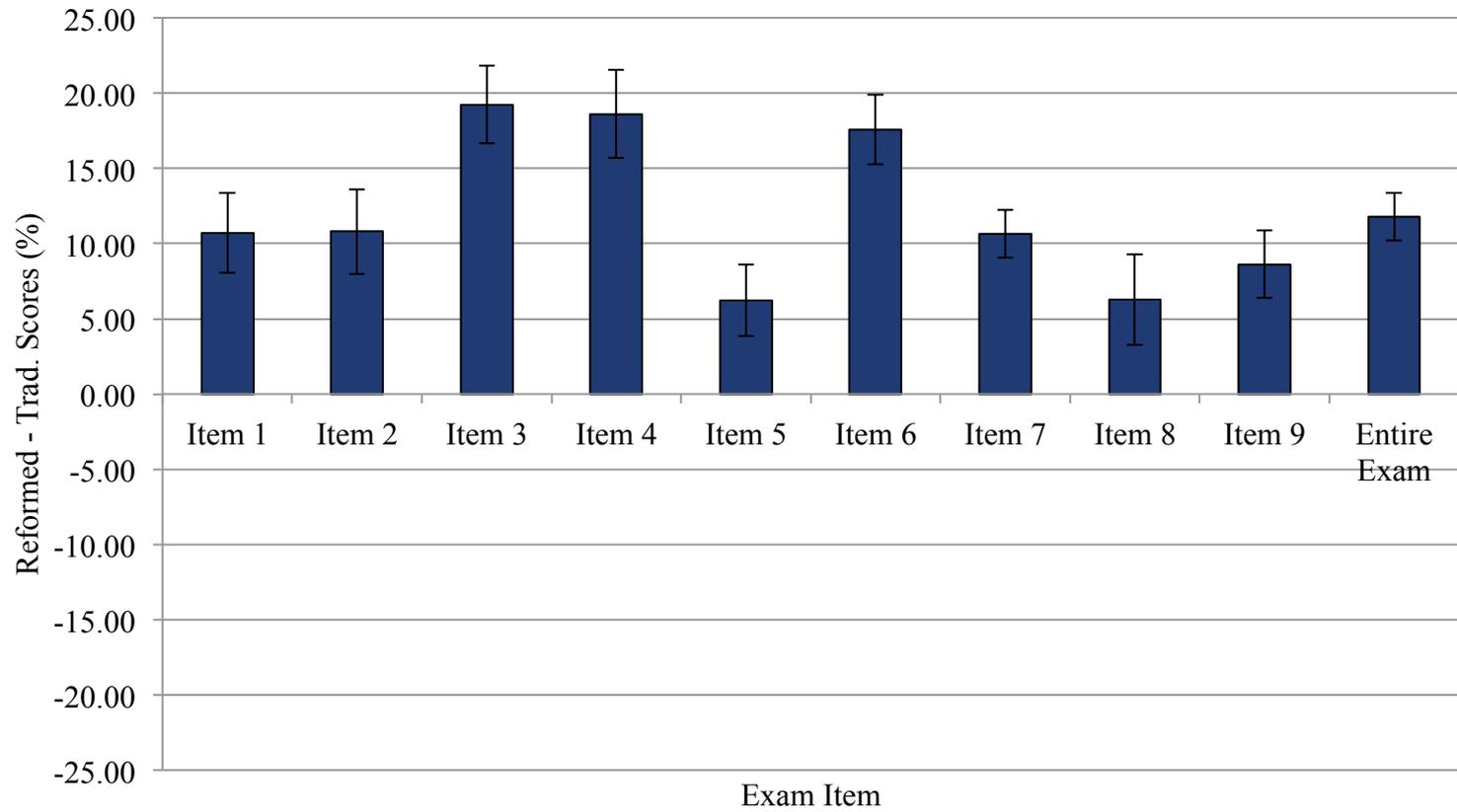
Exam 3



Final Exam



Final Exam



Final Exam

