Specification grading in introductory physics for astronomy and physics majors

Dr. Véronique Petit
Associate Professor
Dept. of Physics & Astronomy
University of Delaware

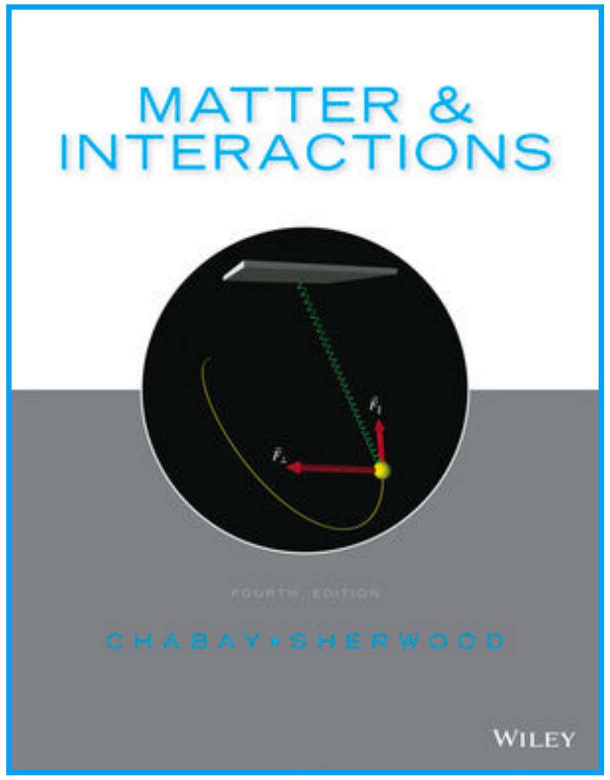
New(ish) Introductory Physics for majors in physics and astronomy

(with calculus)

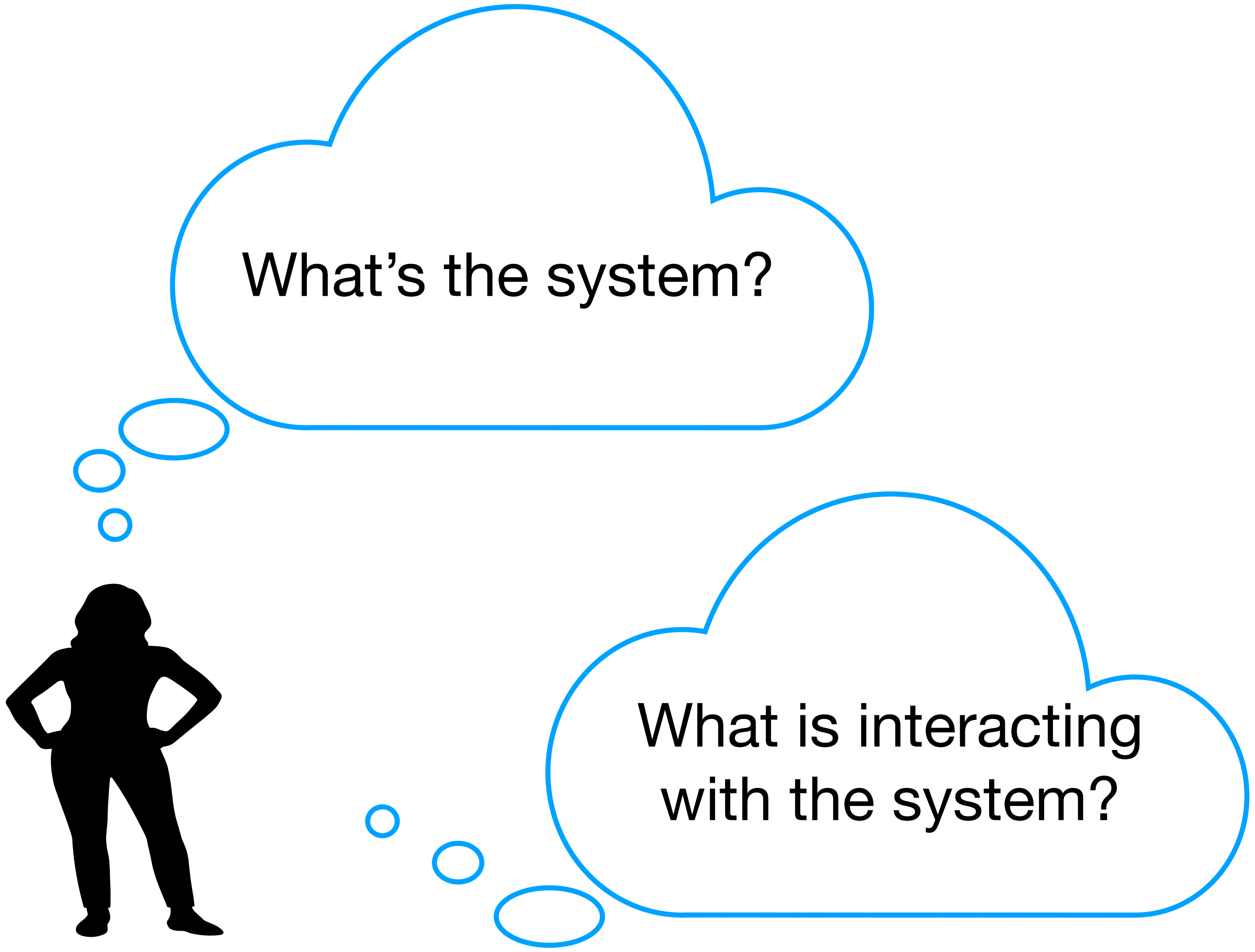
The mission purpose given to me by the Dept. Chair:

Improve the retention of students in our programs

Improve their academic preparation for upper-level physics courses

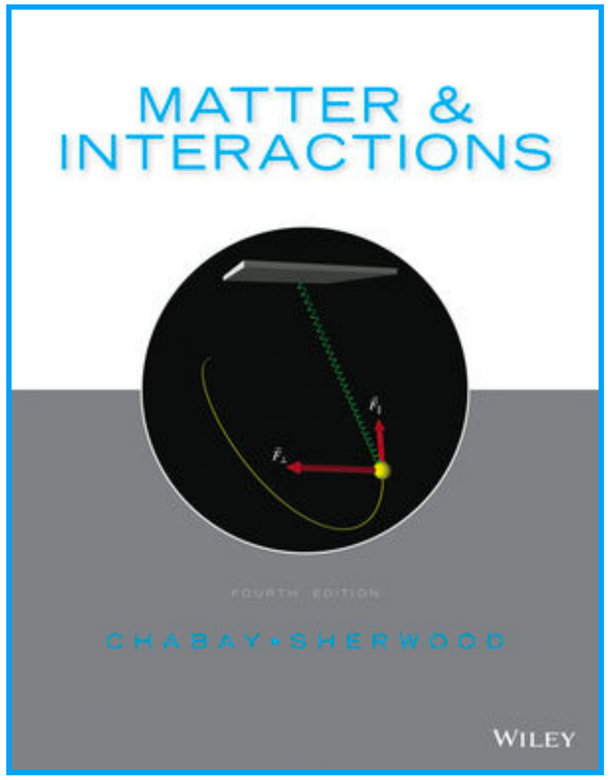


Main narrative: Interactions between objects dictates the motion of objects



What's the system?

What is interacting with the system?



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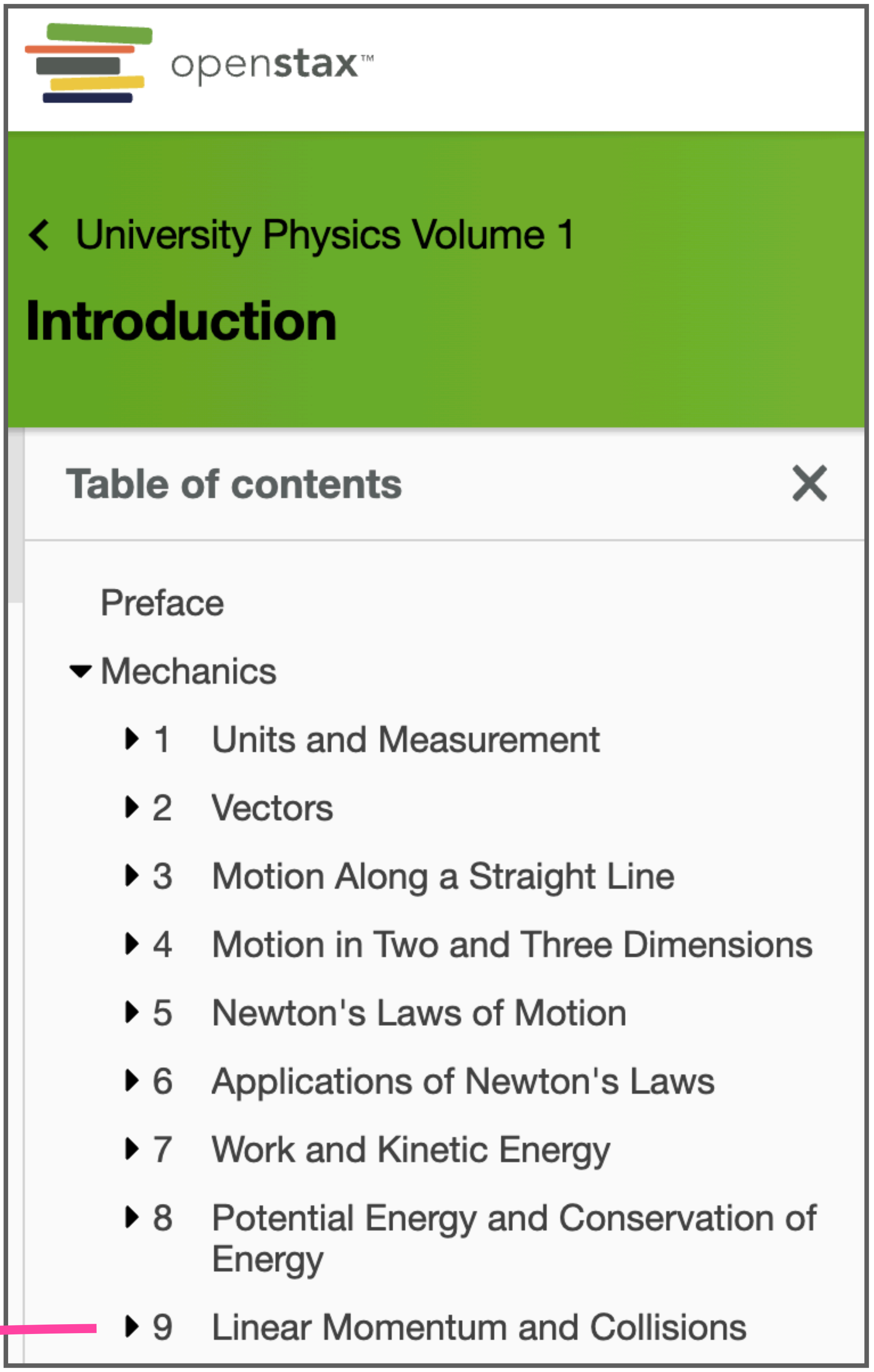
VOLUME I Modern Mechanics



‹ University Physics Volume 1

Introduction

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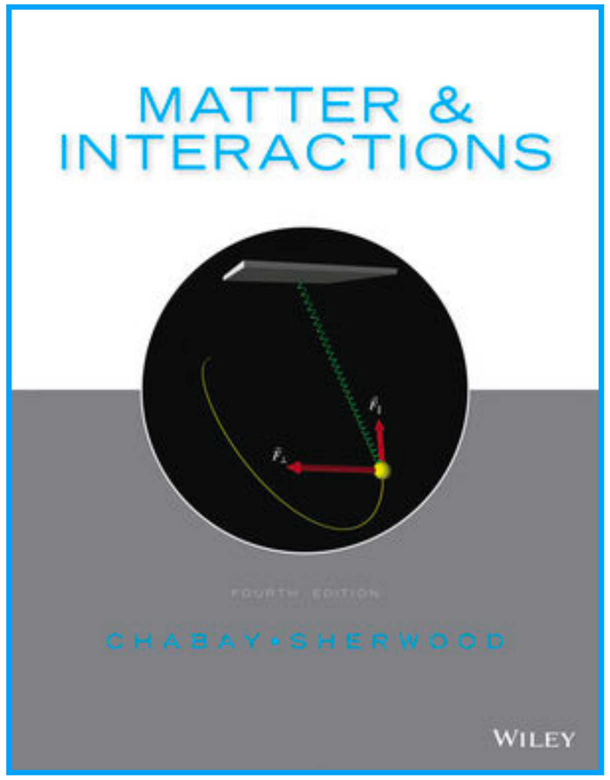
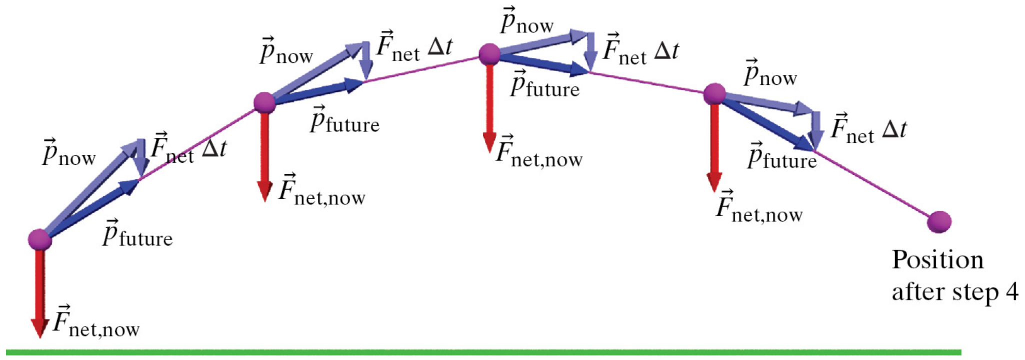
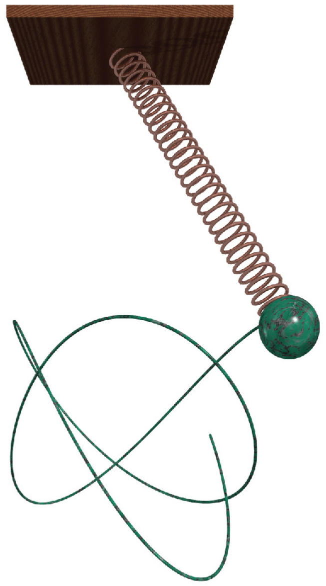
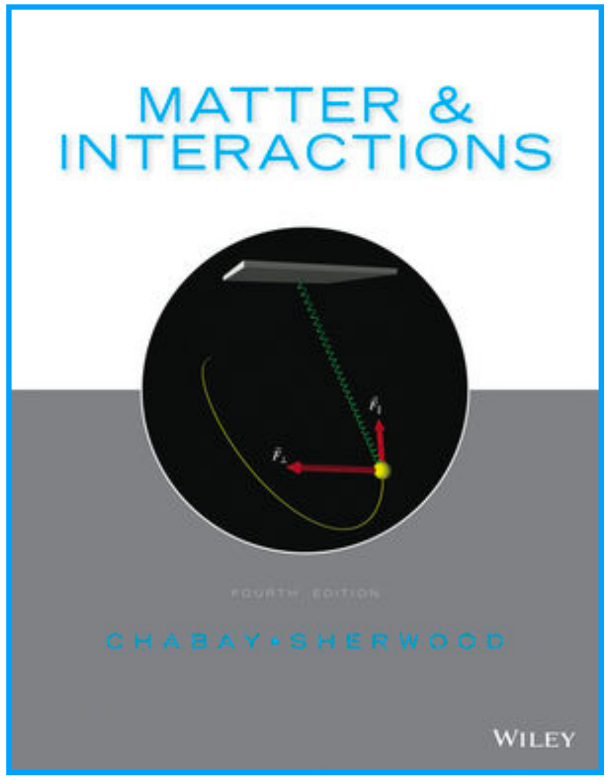


Early emphasis on iterative computation







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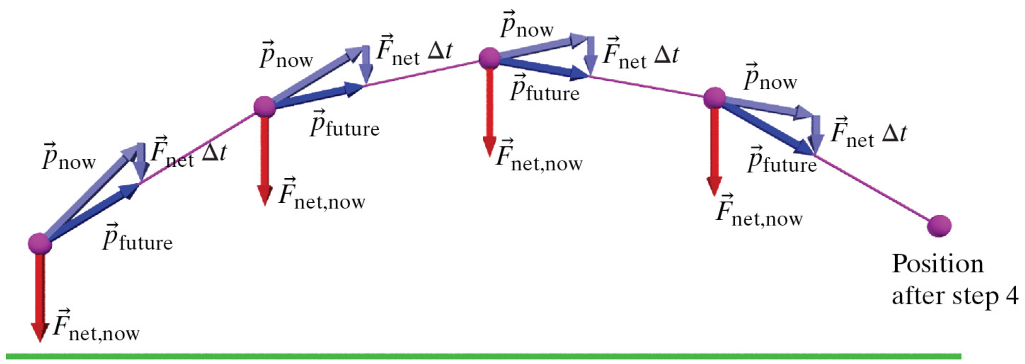
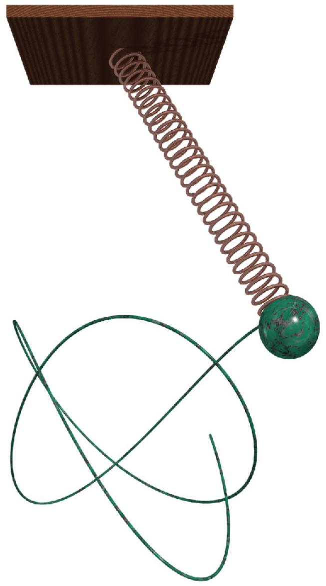
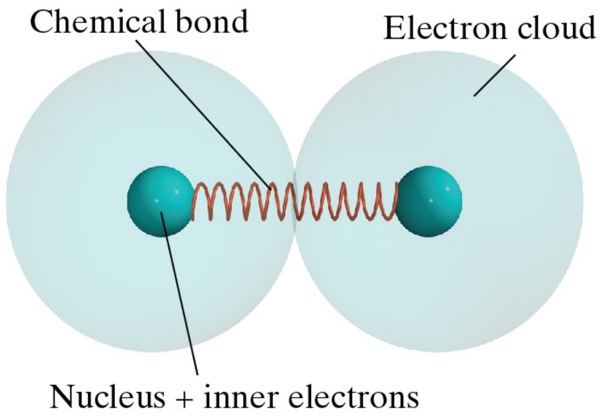
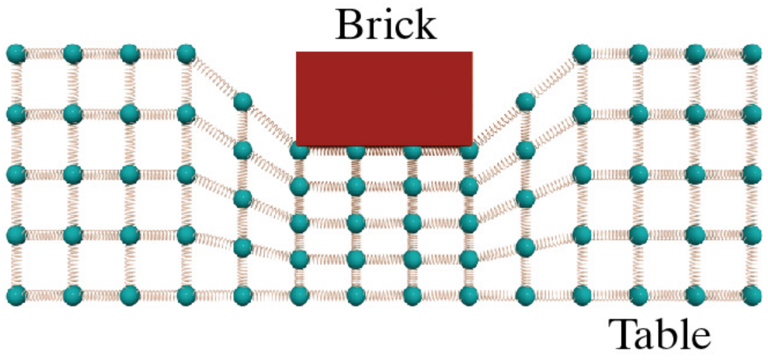




Good linking of all of the concepts and great focus on “why?”.





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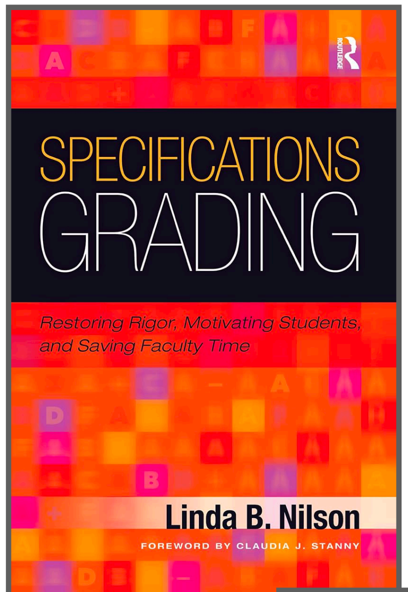
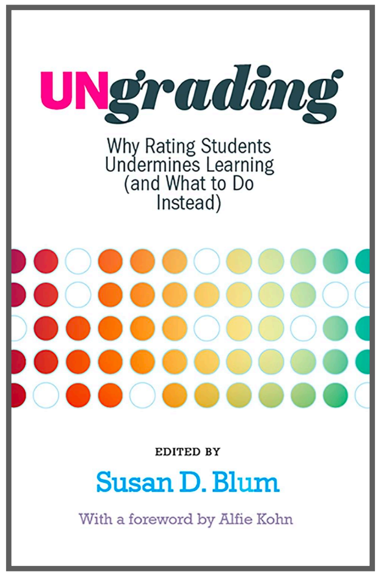
The traditional grading did not really give me a good 'measure' of their preparation


SPECIFICATIONS GRADING

Restoring Rigor, Motivating Students, and Saving Faculty Time

Linda B. Nilson

FOREWORD BY CLAUDIA J. STANNY

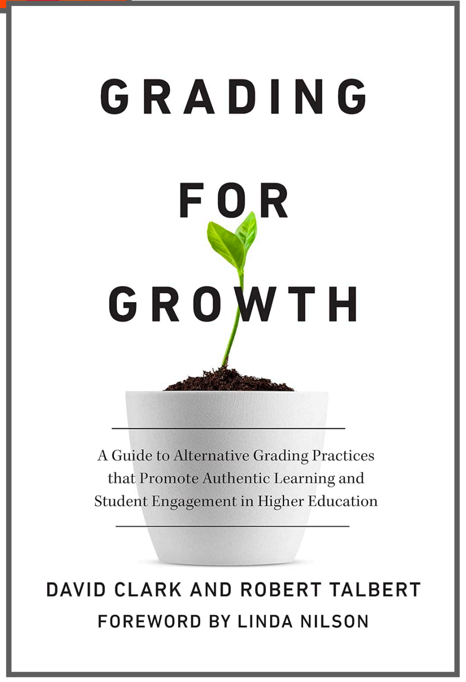

UNgrading

Why Rating Students Undermines Learning (and What to Do Instead)

EDITED BY

Susan D. Blum

With a foreword by Alfie Kohn


GRADING FOR GROWTH

A Guide to Alternative Grading Practices that Promote Authentic Learning and Student Engagement in Higher Education

DAVID CLARK AND ROBERT TALBERT

FOREWORD BY LINDA NILSON

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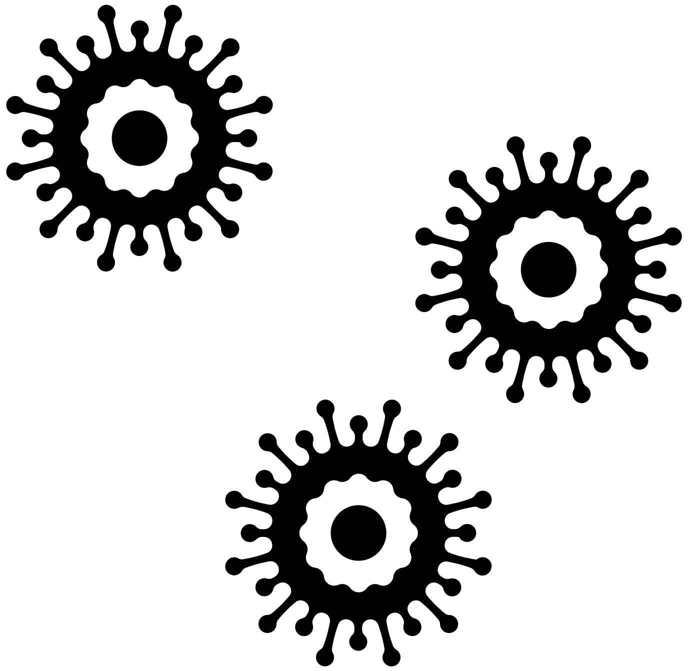

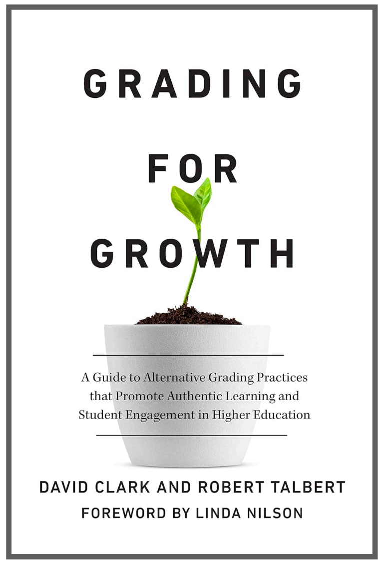

GRADING FOR GROWTH

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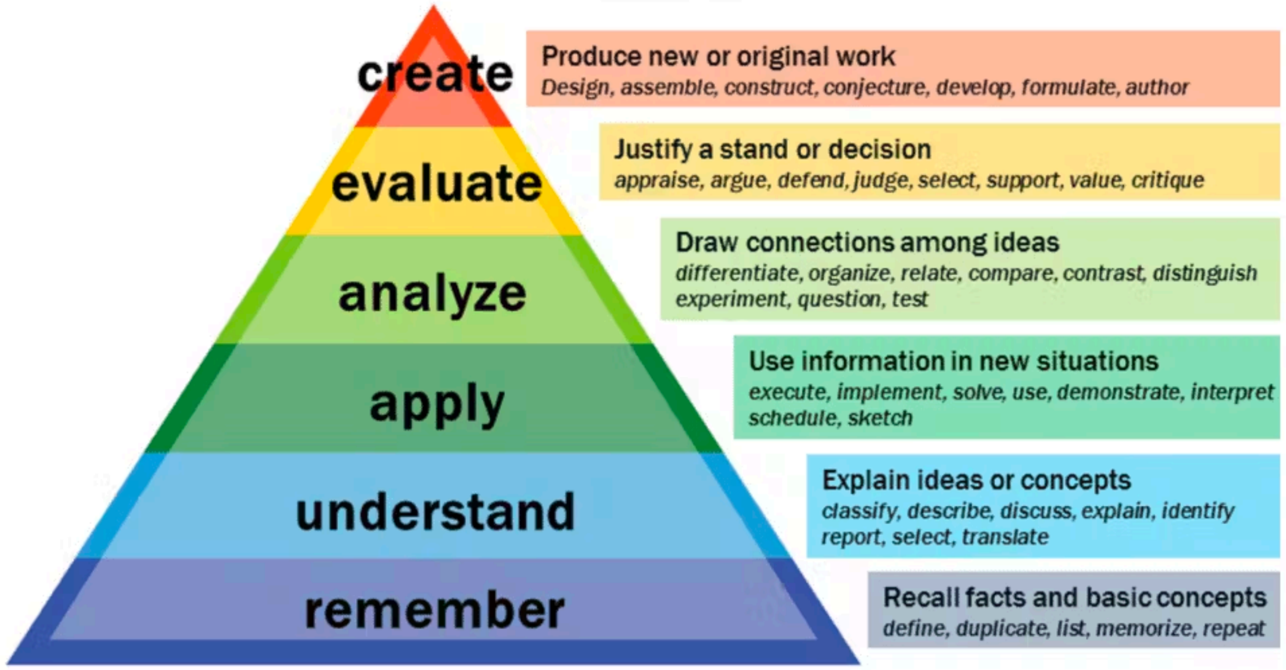
DAVID CLARK AND ROBERT TALBERT
FOREWORD BY LINDA NILSON

IN FEEDBACK LOOPS WE TRUST

- CLEARLY DEFINED STANDARDS
- HELPFUL FEEDBACK
- MARKS INDICATE PROGRESS
- REATTEMPTS WITHOUT PENALTY

Bloom's Taxonomy



create — Produce new or original work
Design, assemble, construct, conjecture, develop, formulate, author

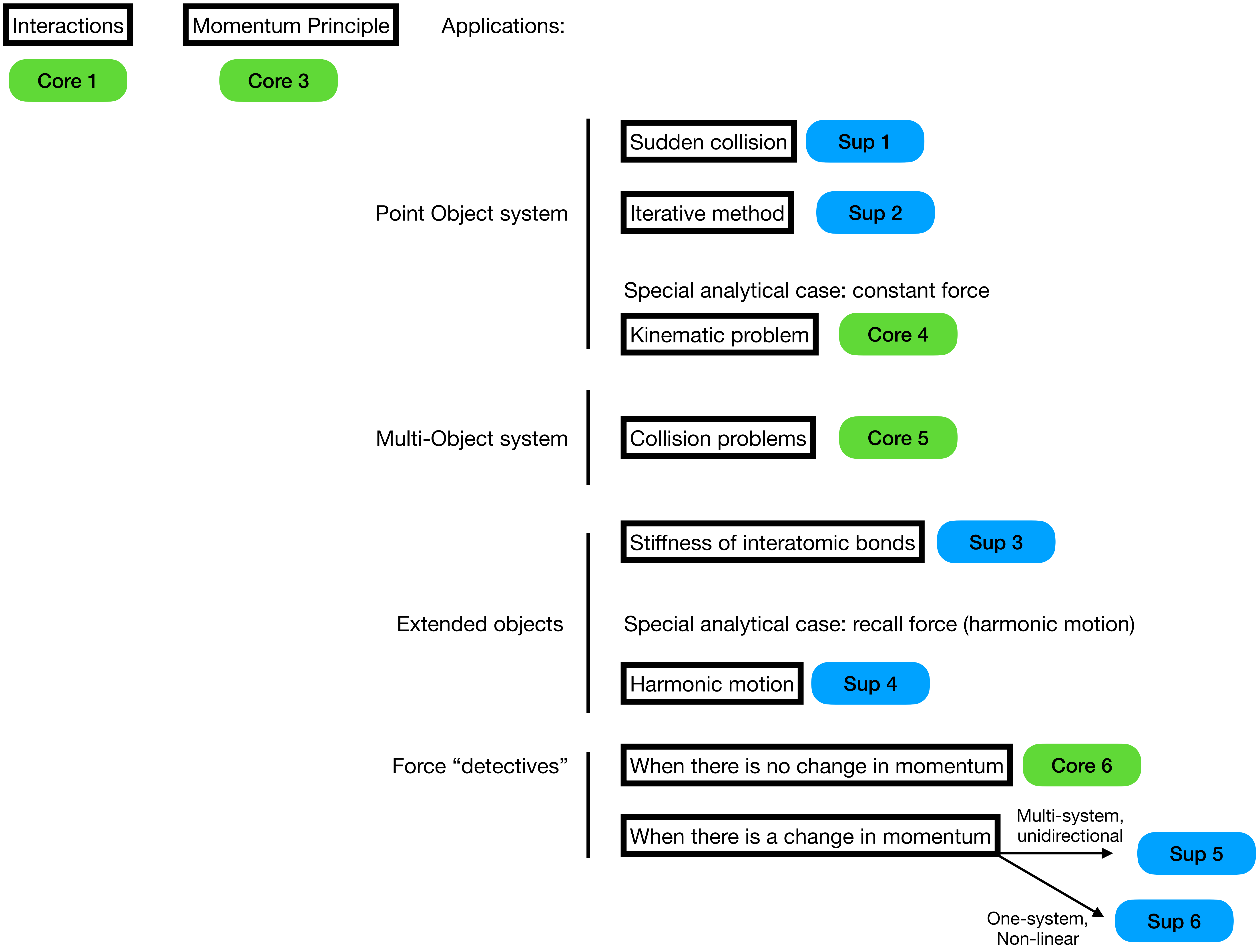
evaluate — Justify a stand or decision
appraise, argue, defend, judge, select, support, value, critique

analyze — Draw connections among ideas
differentiate, organize, relate, compare, contrast, distinguish experiment, question, test

apply — Use information in new situations
execute, implement, solve, use, demonstrate, interpret schedule, sketch

understand — Explain ideas or concepts
classify, describe, discuss, explain, identify report, select, translate

remember — Recall facts and basic concepts
define, duplicate, list, memorize, repeat



Interactions
Core 1

Momentum Principle
Core 3

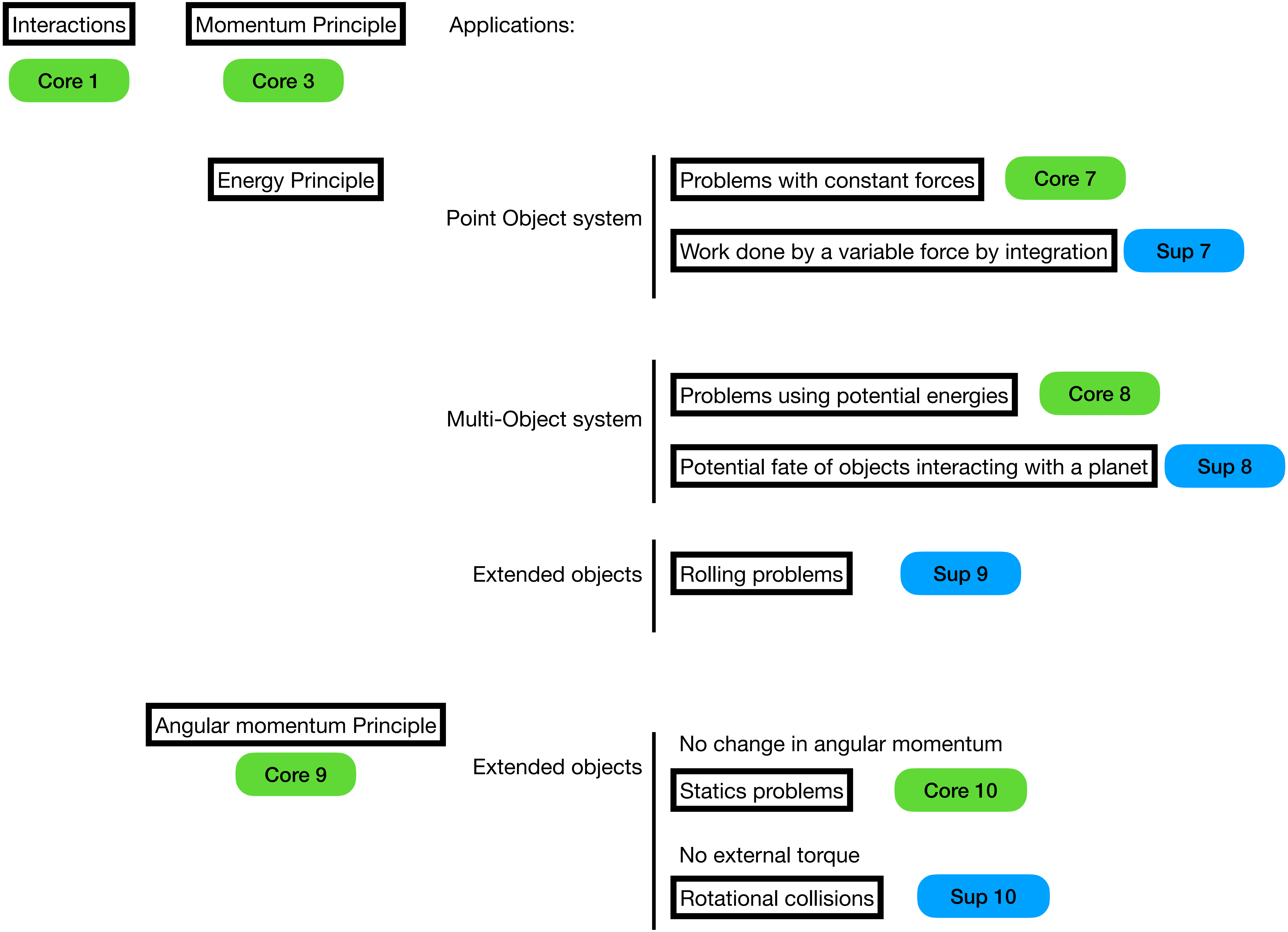
Applications:

Point Object system
- Sudden collision — Sup 1
- Iterative method — Sup 2
- Special analytical case: constant force
- Kinematic problem — Core 4

Multi-Object system
- Collision problems — Core 5

Extended objects
- Stiffness of interatomic bonds — Sup 3
- Special analytical case: recall force (harmonic motion)
- Harmonic motion — Sup 4

Force “detectives”
- When there is no change in momentum — Core 6
- When there is a change in momentum
  - Multi-system, unidirectional → Sup 5
  - One-system, Non-linear → Sup 6



Interactions

Core 1

Momentum Principle

Core 3

Applications:

Energy Principle

Point Object system

- Problems with constant forces — Core 7
- Work done by a variable force by integration — Sup 7

Multi-Object system

- Problems using potential energies — Core 8
- Potential fate of objects interacting with a planet — Sup 8

Extended objects

- Rolling problems — Sup 9

Angular momentum Principle

Core 9

Extended objects

No change in angular momentum

- Statics problems — Core 10

No external torque

- Rotational collisions — Sup 10

Core 1	I can assess whether an object has **interacted**.
Core 2	I can **find the future position** of an object based on its average velocity or its momentum (relativistic or not).
Core 3	I can use logical, non-quantitative but mathematical **reasoning** to deduce the direction of p_{future}, F_{net} or p_{now}, given the other two.
Core 4	I can solve a **kinematic problem** with multiple unknowns
Core 5	I can solve a **collision problem** with conservation of momentum
Core 6	I can solve a "detective" problem with multiple unknowns, that requires considering more than one system, when the **change in momentum is zero**
Core 7	I can solve a problem using the **energy principle**, when the forces are constants with a point particle system
Core 8	I can solve a problem using the energy principle with a multi-object system and the concept of **potential energy**
Core 9	I can calculate the angular momentum of a system and the torque applied by a force to a system.
Core 10	I can solve a **statics problem** with multiple unknowns using the momentum and angular momentum

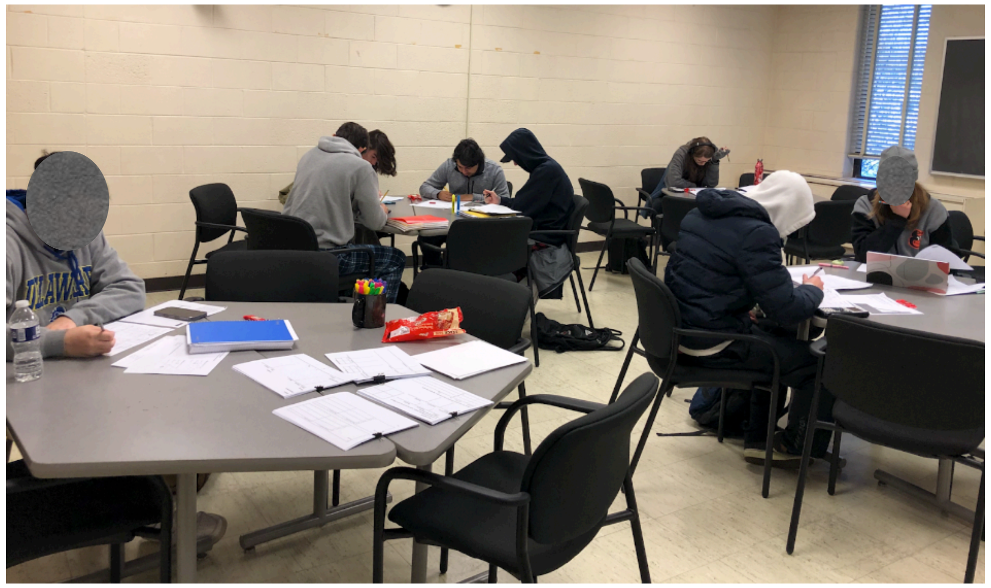
Sup 1	I can estimate the impact force in a **sudden collision** problem using order of magnitude **estimation**
Sup 2	I can predict motion using the **iterative method** with a variable force (springs)
Sup 3	I can find the stiffness of an **interatomic bond** based on experimental data
Sup 4	I can use the properties of a **harmonic oscillator** to analytically predict something about a mass-spring system
Sup 5	I can solve a "detective" problem with multiple unknowns, that requires considering more than one system, when the **change in momentum is not zero but unidirectional**
Sup 6	I can solve a "detective" problem with multiple unknowns, that requires one system, when the **change in momentum is not zero and non-linear**
Sup 7	I can calculate the **work** done by a variable force with integration
Sup 8	I can relate the graph of energies versus separation to determine the **potential fate** of the object
Sup 9	I can solve a **rolling problem** with the energy principle
Sup 10	I can solve a **rotational collision problem**

A 4-credit college course = 12 hours

(PHYS 207 + 227)

Example schedule

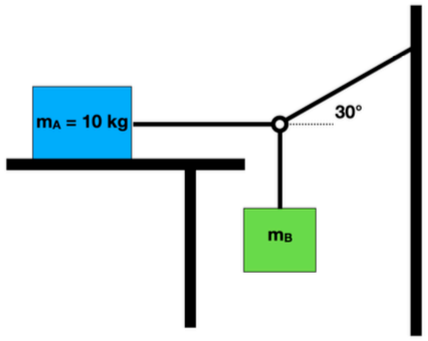
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
What is happening in class (10:10-11:00) (11:15-12:05)	Mini-lectures, practice, discussions		Mini-lectures, practice, discussions		Practice, practice, practice		
What is happening in lab (7:00-9:00)			PHYS 227: Lab activity				
What is happening outside of class	Work on a lab writeup (227) / WP (207)	PHYS 227: Work on Lab prep PHYS 227: Work on a lab writeup		Work on Daily Prep 'Fri' Work on WP exercises	Work on Daily Prep 'Mon'		
What is due?			* Lab Prep	* Daily Prep 'Fri'			* Daily Prep 'Mon' * Wiley Plus exercises * May submit up to two Labs



Learning Target Core 6: I can solve a "detective" problem with multiple unknowns, that requires considering more than one system, when the **change in momentum is zero**

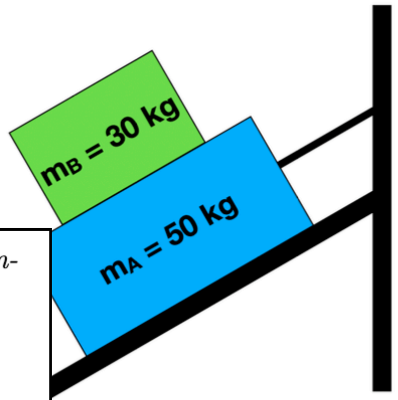
Learning Target Core 6 *I can solve a "detective" problem with multiple unknowns, that requires considering more than one system, when the change in momentum is zero*

A block rest on a table. The coefficient of static friction between the table and the block is 0.25. The block is connected by a rope to a ring of negligible mass, which is itself connected to a rope attached
(making a 30○ angle with the horizontal) and to a vertical rope from which another box is hangi
is the maximum mass for the hanging box, so that the box on the table does not move? (Hint, I
systems: the box on the table, the hanging box, and the ring holding the ropes.



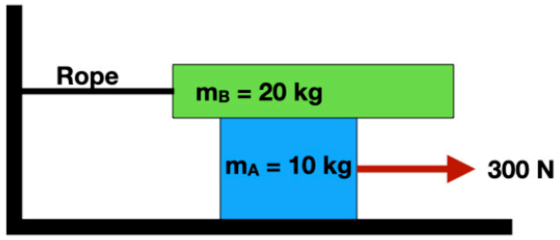
Learning Target Core 6 *I can solve a "detective" problem with multiple unknowns, that requires considering more than one system, when the change in momentum is zero*

Box A is sitting still on a ramp, which is inclined at 30° with respect to the horizontal. There is no friction between the ramp and Box A. Box A is attached to a wall by a rope of negligible mass. Block B sits on top of Block A and does not slide. Find the minimum coefficient of static friction between the two blocks, and the tension in the rope. Tilt your coordinate system so that the x-axis points up the ramp.



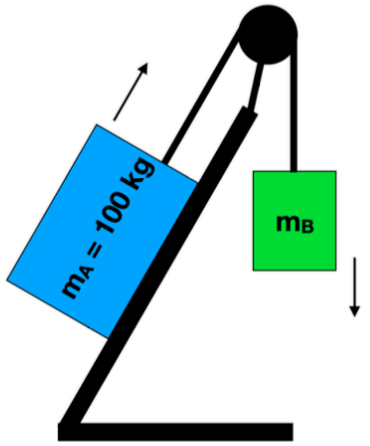
Learning Target Core 6 *I can solve a "detective" problem with multiple unknowns, that requires considering more than one system, when the change in momentum is zero*

On a table, a block of mass $m_{\mathrm{B}} = 20$ kg is placed on top of another block of mass $m_{\mathrm{A}} = 10$ kg. The top block is attached to the wall on the left by a rope. The mass of the rope is very small, and the rope is horizontal. There is friction between the bottom block and the table, as well as between
The coefficients of friction are the same between all surfaces. You pull on the bottom block
300 N. The block moves to the right with a constant velocity. Solve for the tension in the r



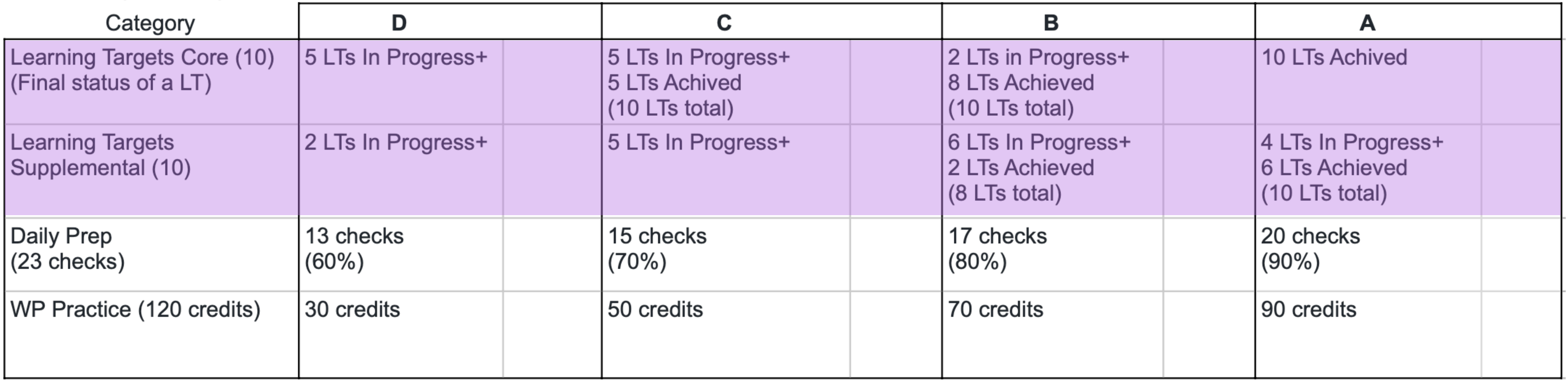
Learning Target Core 6 *I can solve a "detective" problem with multiple unknowns, that requires considering more than one system, when the change in momentum is zero*

Box A (100 kg) is placed on a ramp, which is inclined at 60° with respect to the horizontal. The coefficient of kinetic friction between the ramp and Box A is 0.6 and the coefficient of static friction is 0.7. Box A is attached by rope of negligible mass to Block B. The rope passes over a pulley (the black circle on the diagram) and Block B is hanging on the other side of the ramp. If Block B is **moving downward at *constant speed***, what is the mass of Block B?



	D	C	B	A
Categories of graded work	How many “satisfactory” pieces of work needed in each category to get this grade			

PHYS 207 (3 credits)



Category	D	C	B	A
Learning Targets Core (10) (Final status of a LT)	5 LTs In Progress+	5 LTs In Progress+ 5 LTs Achived (10 LTs total)	2 LTs in Progress+ 8 LTs Achieved (10 LTs total)	10 LTs Achived
Learning Targets Supplemental (10)	2 LTs In Progress+	5 LTs In Progress+	6 LTs In Progress+ 2 LTs Achieved (8 LTs total)	4 LTs In Progress+ 6 LTs Achieved (10 LTs total)
Daily Prep (23 checks)	13 checks (60%)	15 checks (70%)	17 checks (80%)	20 checks (90%)
WP Practice (120 credits)	30 credits	50 credits	70 credits	90 credits

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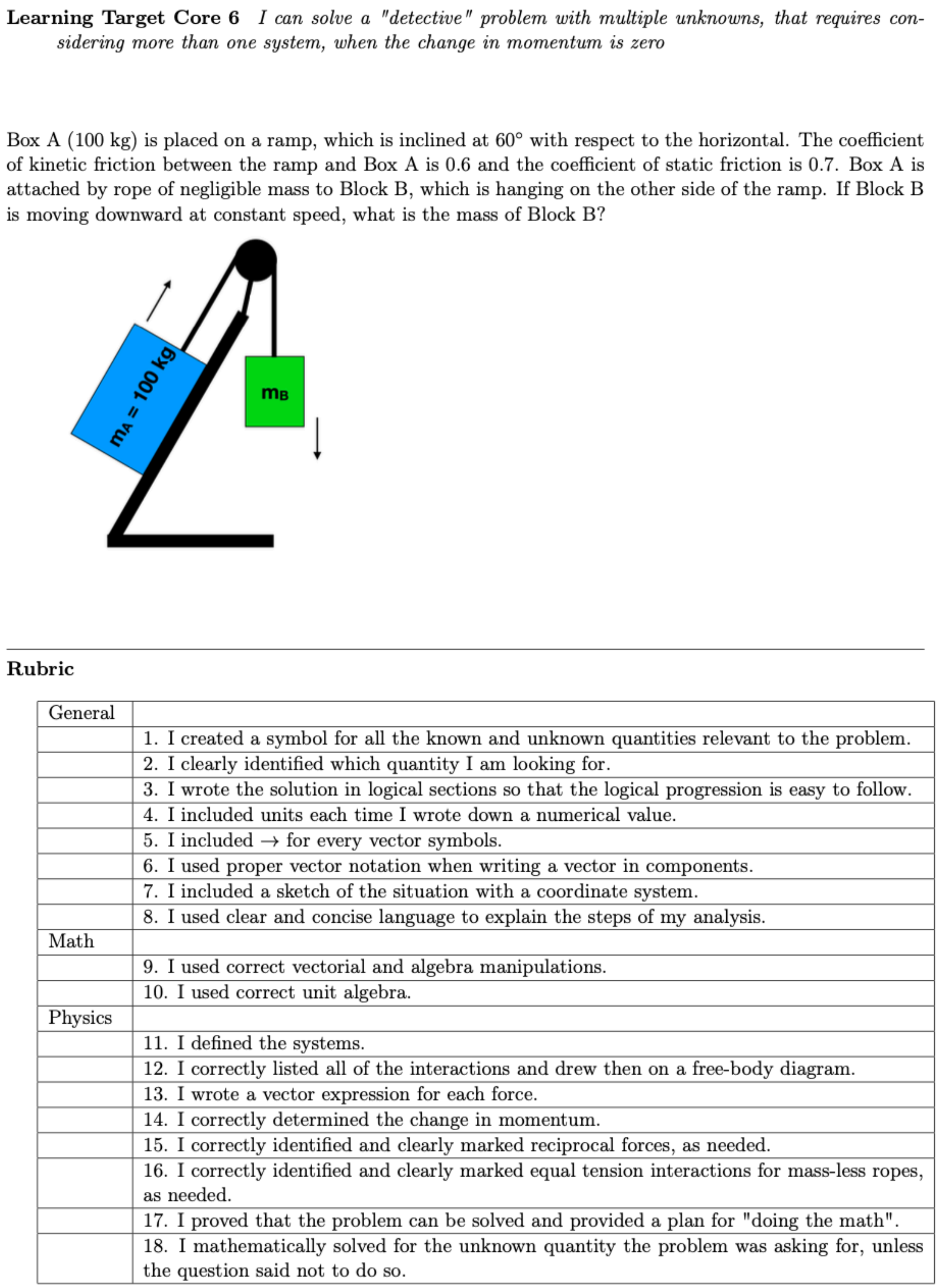

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Rubric

General	
	1. I created a symbol for all the known and unknown quantities relevant to the problem.
	2. I clearly identified which quantity I am looking for.
	3. I wrote the solution in logical sections so that the logical progression is easy to follow.
	4. I included units each time I wrote down a numerical value.
	5. I included → for every vector symbols.
	6. I used proper vector notation when writing a vector in components.
	7. I included a sketch of the situation with a coordinate system.
	8. I used clear and concise language to explain the steps of my analysis.
Math	
	9. I used correct vectorial and algebra manipulations.
	10. I used correct unit algebra.
Physics	
	11. I defined the systems.
	12. I correctly listed all of the interactions and drew then on a free-body diagram.
	13. I wrote a vector expression for each force.
	14. I correctly determined the change in momentum.
	15. I correctly identified and clearly marked reciprocal forces, as needed.
	16. I correctly identified and clearly marked equal tension interactions for mass-less ropes, as needed.
	17. I proved that the problem can be solved and provided a plan for "doing the math".
	18. I mathematically solved for the unknown quantity the problem was asking for, unless the question said not to do so.

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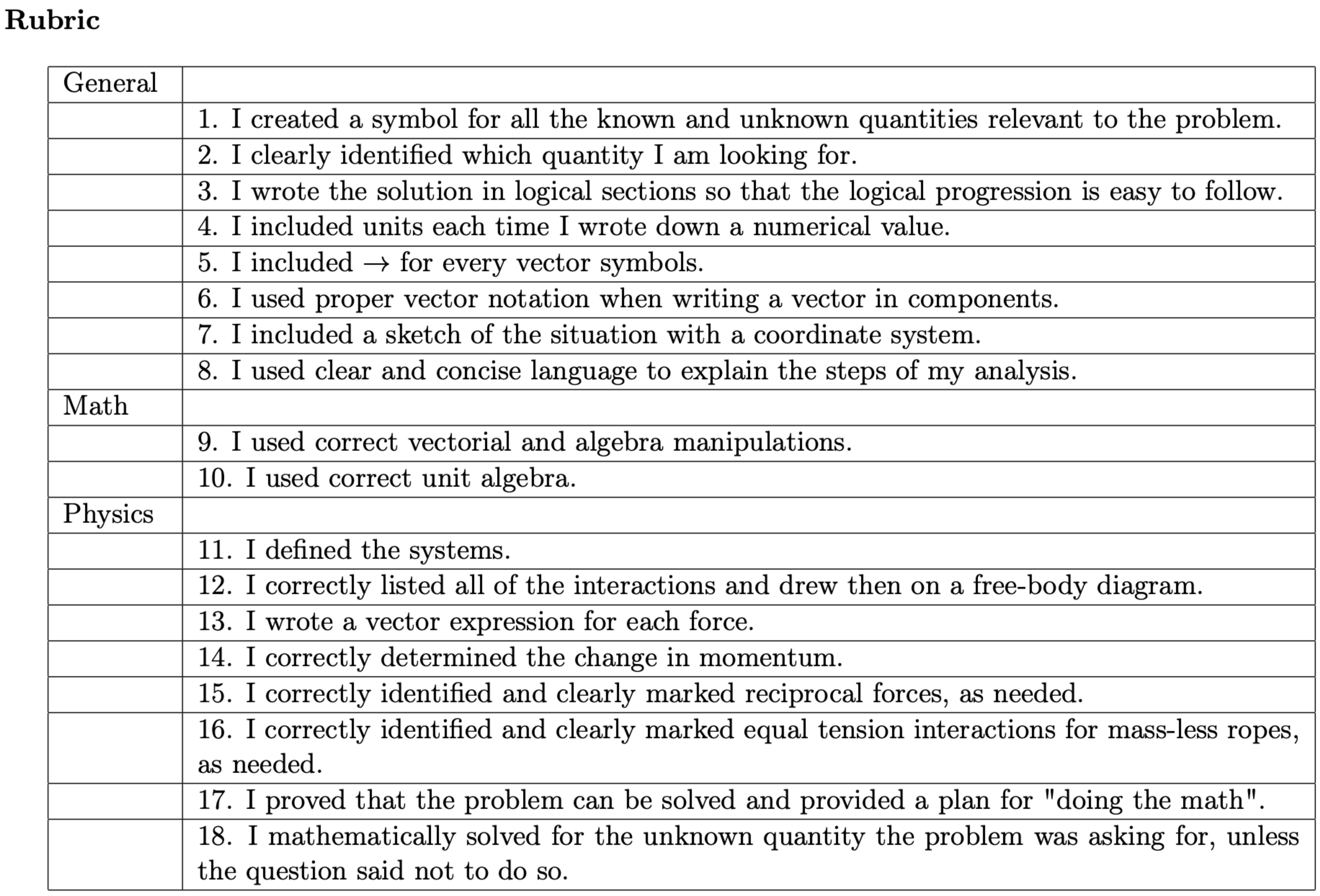

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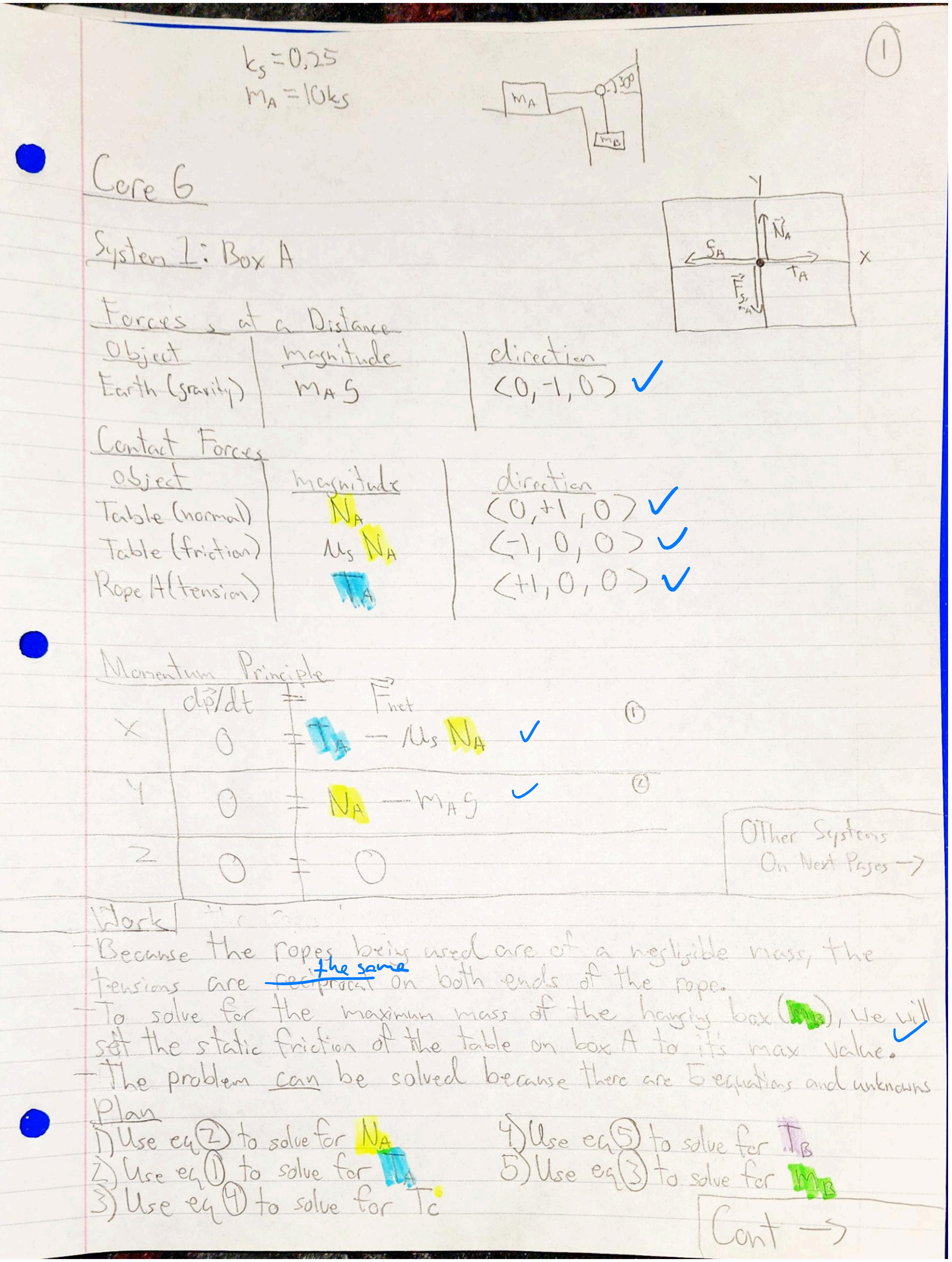


①

$k_s = 0.25$
$m_A = 10kg$

Core 6

System 1: Box A

Forces at a Distance

Object	magnitude	direction
Earth (gravity)	$m_A g$	$\langle 0,-1,0 \rangle$ ✓

Contact Forces

object	magnitude	direction
Table (normal)	N_A	$\langle 0,+1,0 \rangle$ ✓
Table (friction)	$\mu_s N_A$	$\langle -1,0,0 \rangle$ ✓
Rope A (tension)	T_A	$\langle +1,0,0 \rangle$ ✓

Momentum Principle

	$d\vec{p}/dt$	=	$\vec{F}_{net}$		
X	0	=	$T_A - \mu_s N_A$	✓	①
Y	0	=	$N_A - m_A g$	✓	②
Z	0	=	0		

Other Systems On Next Pages →

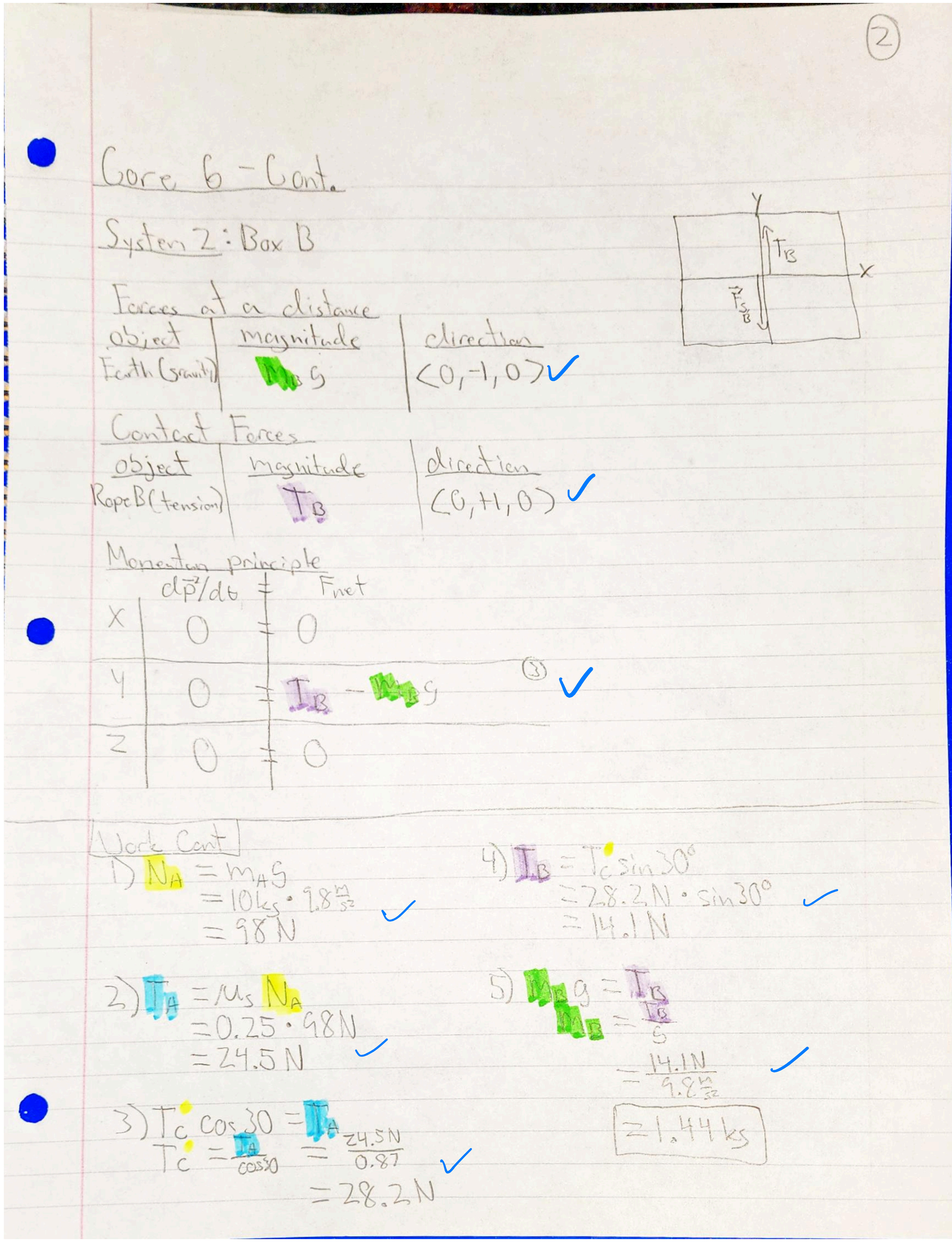
Work

- Because the ropes being used are of a negligible mass, the tensions are ~~reciprocal~~ the same on both ends of the rope.
- To solve for the maximum mass of the hanging box (m_B), we will set the static friction of the table on box A to it's max value. ✓
- The problem can be solved because there are 5 equations and unknowns

Plan

1) Use eq ② to solve for N_A
2) Use eq ① to solve for T_A
3) Use eq ④ to solve for T_c
4) Use eq ⑤ to solve for T_B
5) Use eq ③ to solve for m_B

Cont →



②

Core 6 - Cont.

System 2: Box B

Forces at a distance

object	magnitude	direction
Earth (gravity)	$m_B g$	$\langle 0,-1,0 \rangle$ ✓

Contact Forces

object	magnitude	direction
Rope B (tension)	T_B	$\langle 0,+1,0 \rangle$ ✓

Momentum principle

	$d\vec{p}/dt$	=	F_{net}		
X	0	=	0		
Y	0	=	$T_B - m_B g$	③	✓
Z	0	=	0		

Work Cont

1) $N_A = m_A g$
$= 10kg \cdot 9.8\frac{m}{s^2}$
$= 98N$ ✓

2) $T_A = \mu_s N_A$
$= 0.25 \cdot 98N$
$= 24.5N$ ✓

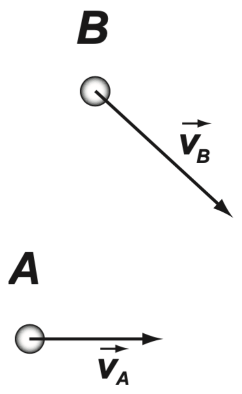
3) $T_c \cos 30 = T_A$
$T_c = \frac{T_A}{\cos 30} = \frac{24.5N}{0.87}$ ✓
$= 28.2N$

4) $T_B = T_c \sin 30°$
$= 28.2N \cdot \sin 30°$ ✓
$= 14.1N$

5) $m_B g = T_B$
$m_B = \frac{T_B}{g}$
$= \frac{14.1N}{9.8\frac{m}{s^2}}$ ✓
$\boxed{= 1.44kg}$

Learning Target Core 5 *I can solve a collision problem with conservation of momentum.*

You throw a 0.5 kg piece of rock that is caught by a 1.5 kg hawk in mid air. Just before the collision between the hawk and the rock, the rock was moving with a speed of 3 m/s in the $+x$ direction, and the hawk was moving with a speed of 10 m/s in a direction 30° below the horizontal (see sketch). If the hawk does not let go of the rock, what is the velocity of the hawk+rock just after the collision? (Remember to justify in words the approximations you made about the forces on the system.)



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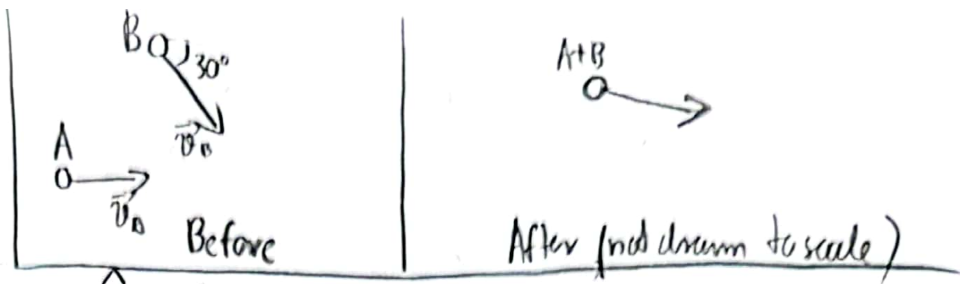
Math	
	9. I used correct vectorial and algebra manipulations.
	10. I used correct unit algebra.
Physics	
	11. I correctly calculated the momentum of a system containing multiple point objects.
	12. I correctly applied the momentum principle.
	13. I justified the approximations I made about the forces on the system.

Core 5



$m_{rock} = m_A = 0.5kg$

$\vec{v}_{rock} = \vec{v}_A = \langle 3,0,0 \rangle \frac{m}{s}$

$\hat{v}_2 = \langle \cos 30°, -\sin 30°, 0 \rangle$

$m_{hawk} = m_2 = 1.5kg$

$\vec{v}_2 = \vec{v}_{hawk} = \langle 10\cos 30°, -10\sin 30°, 0 \rangle \frac{m}{s}$

system: rock + hawk
surr: The Gravity of Earth X]
* Air X

We have to assume that the gravity is not important in this case, because the masses of the objects are small, AND the time interval of impact was very quick (hawk moving at $10\frac{m}{s}$ snatching rock moving $3\frac{m}{s}$ would be a very quick interaction, maybe less than second or half a second or even more)

We can do same for Air, because mass is big and ~~they~~ the rock might be very small, and hawk tightens up before impact.

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$$\boxed{- \quad \vec{P}_{sys,f} = \vec{P}_{sys,i} + \overset{0}{\cancel{\vec{F}_{net}}}\Delta t}$$

1) $\vec{P}_{sys,f} = \vec{P}_{sys,i}$

2) $\vec{P}_{f\,sys} = \vec{P}_{Af} + \vec{P}_{Bi} =$

$= 0.5kg \cdot \langle 3,0,0 \rangle \frac{m}{s} + 1.5kg \langle 10\cos 30°, -10\sin 30°, 0 \rangle \frac{m}{s} =$

$= \langle 1.5,0,0 \rangle \frac{kg\,m}{s} + \langle 12.99, -7.5, 0 \rangle \frac{kg\,m}{s} =$

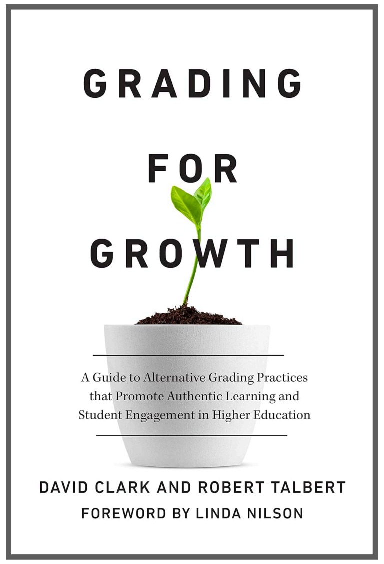
$= \langle 14.5, -7.5, 0 \rangle \frac{kg\,m}{s}$

3) $\vec{P}_{f\,sys} = \vec{P}_{sys\,i} = \langle 14.5, -7.5, 0 \rangle \frac{kg\,m}{s}$

4) Since the hawk doesn't let go of the rock, the velocity of a rock AND a hawk will be the same.

$\vec{P}_{sys,f} = m_{sys} \times \vec{v}_{sys,f} \qquad \vec{v}_{sys,f} = \frac{\vec{P}_{sys,f}}{m_{sys}} = \frac{\langle 14.5, -7.5, 0 \rangle \frac{kg\,m}{s}}{0.5kg + 1.5kg} =$

$= \langle 7.245, -3.75, 0 \rangle \frac{m}{s}$



GRADING FOR GROWTH

A Guide to Alternative Grading Practices that Promote Authentic Learning and Student Engagement in Higher Education

DAVID CLARK AND ROBERT TALBERT

FOREWORD BY LINDA NILSON

IN FEEDBACK LOOPS WE TRUST

CLEARLY DEFINED STANDARDS

HELPFUL FEEDBACK

MARKS INDICATE PROGRESS

REATTEMPTS WITHOUT PENALTY

➡How to avoid the ‘snowball effect’ ?

➡Is it equitable ?

➡How can this be more simplified ?

Useful resources:

- Grading for Growth blog: https://gradingforgrowth.com/
- alternativegrading.slack.com (there is a Physics channel)
- Blog of Robert Talbert https://rtalbert.org/ (Mathematics Dept. at Grand Valley State University

  Who I would like to thank for making whole courses available
  on https://github.com/RobertTalbert