Welcome!

oather@PhluidPhysics.com

- # Oather Strawderman

- Science Department Chair @ Lawrence Free State High School in Lawrence, Kansas

- AP Physics teacher since 1997

- International Lead AP Physics Consultant since 2013

- Leader at AP Physics Reading since 2012

- Chair of AP Physics Development Committee

- Lead Instructor for AP Classroom

- AP Physics Item Writer and Reviewer

- Chair College Board Science Advisory Committee

Lawrence, KS

Introductions

- Name

- Where do you teach?

- How long have you taught Physics/AP Physics?

- Which AP Physics course(s) are you teaching this year?

- What is your favorite Physics topic to teach?

Setting the Stage

- Ask questions and share ideas!

- Participate!!

- Physics

- Switching Seats

- Computers: WiFi & Workshop Resources

- Building logistics: Restrooms

- Workshop Logistics: Breaks / Lunch

Objectives

Participants will:

- Explore each section of the Course and Exam Description (CED) and make connections to the Curricular Requirements
- Develop a semester and/or yearlong instructional plan that incorporates all units, topics and skills of the course, as referenced in the CED.
- Explore the exam design and how students will be assessed in a hybrid-digital environment.
- Identify and explain various instructional strategies and tools that teachers can incorporate in their lesson plans to teach the content and skills in the Course and Exam Description.
- Investigate how AP Classroom can develop skills/practices and be used in lesson plans to reinforce topic and skill/practice connections.

Schedule

8:30am - 10:00am: AM 1 Session

10:00am - 10:15am Tea Break

10:15am - 12:00pm: AM 2 Session

12:00pm - 1:15pm: Lunch

1:15pm - 1:30pm: Check-in

1:30pm - 3:00pm: PM 1 Session

3:00pm - 3:15pm: Tea Break

3:15pm - 4:45pm: PM 2 Session

Saturday October 25

<u>AM1</u>
- Agenda & Introductions
- Exam Overview / Digital Exams / MCQ Section: CED
- Developing the Science Practices

<u>AM2</u>
- Courses Overview / Course & Exam Descriptions/Textbooks
- Year Long Plan
- Mathematical Routines FRQ / The Physics Aviary HW

<u>PM1</u>
- Writing Strategies
- Experimental Design and Analysis FRQ

<u>PM2</u>
- Reading / Mock Reading
- LABS: Diffraction Labs and Fidget Spinner Lab

Sunday October 26

AM1
- Translation Between Representations
- Types of Representation: Diagrams & Sketches

AM2
- AP Classroom / Instructional Planning Reports
- Instructional Strategies / Vocabulary in AP Physics

PM1
- Qualitative/Quantitative Translation FRQs
- Labs: Decay Constant Lab and Density of Air Lab

PM2
- TIPERs & Ranking Tasks
- LAB FRQ Simulation Labs

Contact Info:

www.PhluidPhysics.com

oather@PhluidPhysics.com

Workshop Links & Documents

www.PhluidPhysics.com/Resources
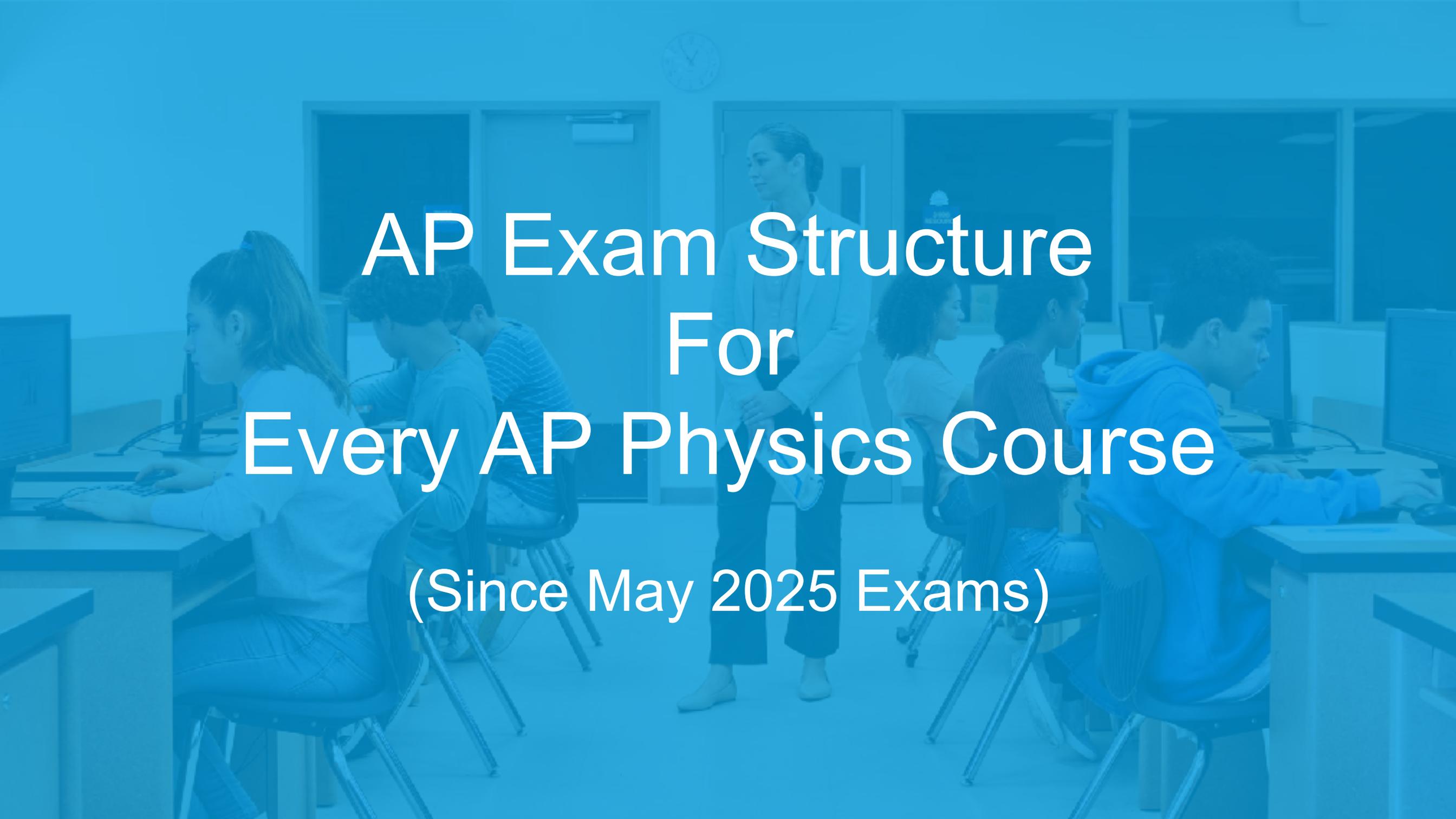
AP Physics 1&2 Websites

apcentral.collegeboard.org/courses/ap-physics-1

apcentral.collegeboard.org/courses/ap-physics-2

AP Exam Structure
For
Every AP Physics Course

(Since May 2025 Exams)

Exam Structure

- **Section 1: Multiple-Choice (50%) DIGITAL**
  - 40 questions, 80 minutes
  - One correct answer
  - Four answer choices

- **Section 2: Free-Response (50%) HYBRID DIGITAL**
  - 4 questions, 100 minutes, 40 points
    1. Mathematical Routines (10 points)
    2. Translating Between Representations (12 points)
    3. Experimental Design and Analysis (10 points)
    4. Qualitative/Quantitative Translation (8 points)
  - **Same order of Free-Response Questions for every course on every exam**

Free-Response Question Types: In this Order

- **Mathematical Routines**
  - Emphasizes problem-solving, calculations, and derivations.

- **Translation Between Representations**
  - Emphasizes fluency between various representations of physical phenomena

- **Experimental Design and Analysis**
  - Design an experiment, analyze the results of an experiment

- **Qualitative/Quantitative Translation**
  - Emphasizes fluency between conceptual and mathematical descriptions of physical phenomena

Exam Information

- Each Multiple Choice Question and Free Response Question point assesses relevant physics content using a given Science Practice

- All content may be assessed with any Science Practice

- **All AP Physics courses have nearly identical exam structures**

- **Exam Dates 2026**

  - P1: Wednesday May 6 PM

  - P2: Thursday May 7 AM

  - Mech: Wednesday May 13 PM

  - E&M: Thursday May 14 PM

AP Physics
Exam Section 1:
Multiple
Choice
Questions

Multiple Choice Questions Activity

- Turn to the following pages in the CED:

  - P1 page 183

  - P2 page 195

- Answer the MCQ items in the CED

- Write down your answer to each question on paper

- Focus on both the content of the questions as well as how the questions are formatted and how they ask students to demonstrate their Physics knowledge

Discussion Topics

- What are some things that stick out about the questions…format and content?

- What struggles could your students have with the questions?

- What instructional strategies will you employ to help your students be successful on this section of the exam?

- Test taking strategy suggestions?

Informations

- Hybrid Digital
- Pacing/Clock
- Equation Sheets
- Exam Forms
- 10 m/s/s and 10 N/kg
- Discrete Items vs Item Sets
- Calculators, Rulers and Pens/Pencils
- Difficulty and Guessing
- Answers and Rationales

THIS IS A TEST PREVIEW

Blocks A and B, of masses m_A and m_B, respectively, are at rest on a horizontal surface with negligible friction. Block A is attached to the table. Block C of mass m_C is suspended by a string that is tied to Block B and passes over a pulley as shown. The blocks all remain at rest.

Attachment

---
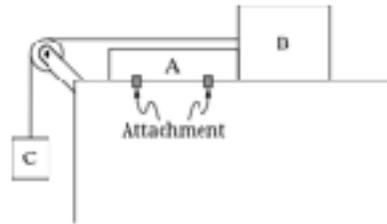
1 ▢ Mark for Review

Which of the following gives the magnitude of the force exerted by Block A on Block B?

(A) $m_B g$

(B) $m_C g$

(C) $\dfrac{m_A m_C g}{m_A + m_B}$

(D) $\dfrac{m_B m_C g}{m_A + m_B}$

Zooming Shortcuts

Section I
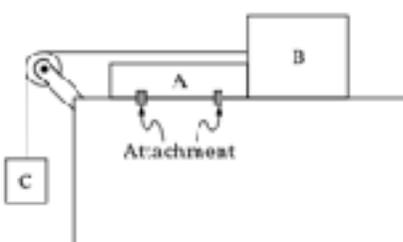Directions ∨
0:00
Hide
Highlights & Notes   Calculator   Reference   More
100%

THIS IS A TEST PREVIEW

Blocks A and B, of masses m_A and m_B, respectively, are at rest on a horizontal surface with negligible friction. Block A is attached to the table. Block C of mass m_C is suspended by a string that is tied to Block B and passes over a pulley as shown. The blocks all remain at rest.

B

A

Attachment

C

1   Mark for Review

Which of the following
force exerted by Block

(A) $m_B g$

(B) $m_C g$

(C) $\frac{m_A m_C g}{m_A + m_B}$

(D) $\frac{m_B m_C g}{m_A + m_3}$

Help

Shortcuts

Assistive Technology

Line Reader

Unscheduled Break

Exit the Exam

Oather Strawderman

Question 1 of 15 ∧

Next

Multiple Choice Section Directions

Section I 0:00

Directions ⌃ (Hide)

The directions that follow are what you will see on exam day. This untimed preview is intended to represent the different question types and functionality you will encounter on exam day and has fewer multiple-choice questions than the exam.

Section I has 40 multiple-choice questions and lasts 1 hour and 20 minutes.

Each of the questions or incomplete statements is followed by four suggested answers or completions. Select the one that is best in each case.

To simplify calculations, you may use $g = 10 \text{ m/s}^2$ in all problems.

A calculator is allowed in this section, as well as a ruler and straightedge. You may use a handheld four-function, scientific, or graphing calculator, or the calculator available in this application.

Reference information, including lists of equations, is available in this application and can be accessed throughout the exam.
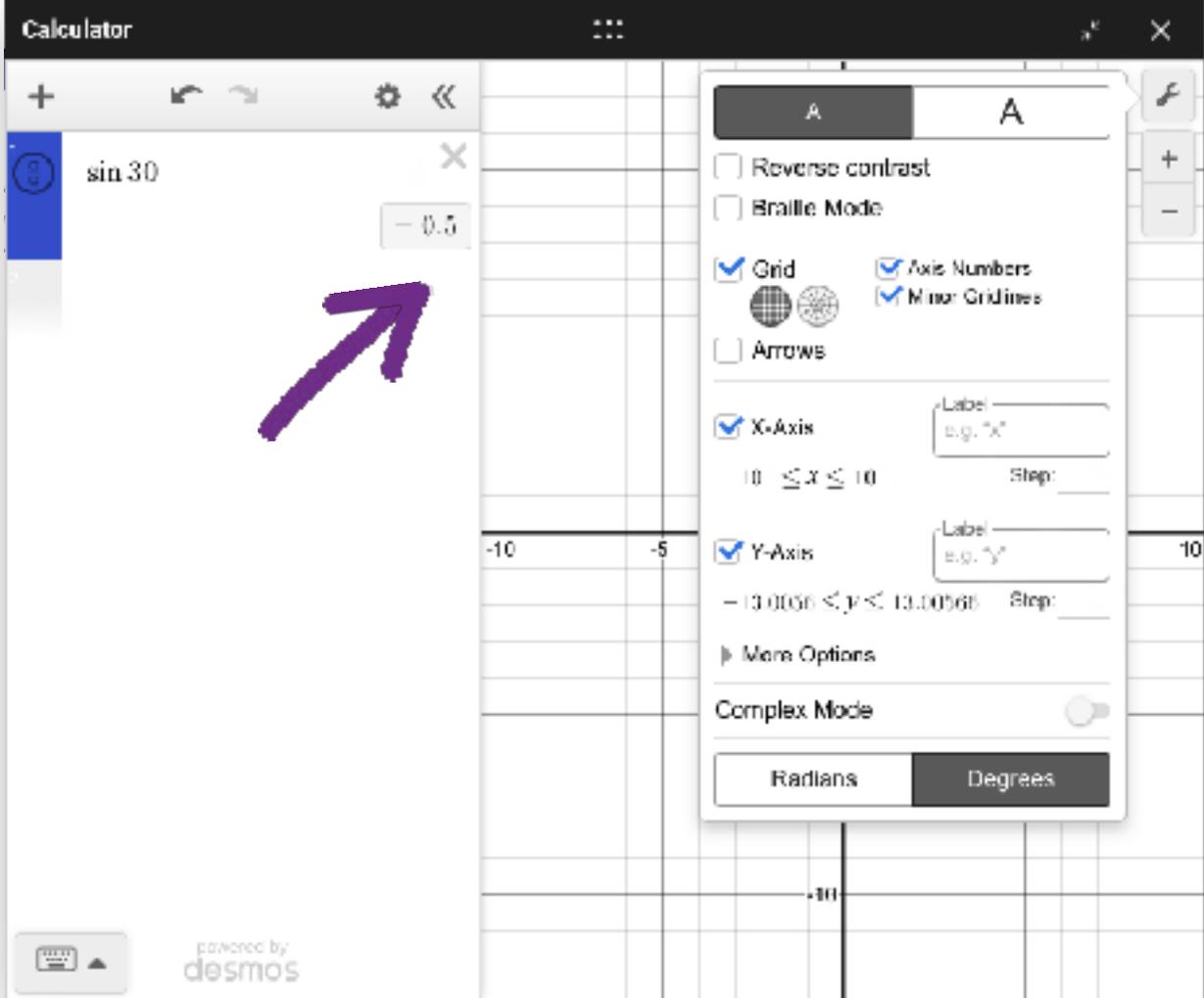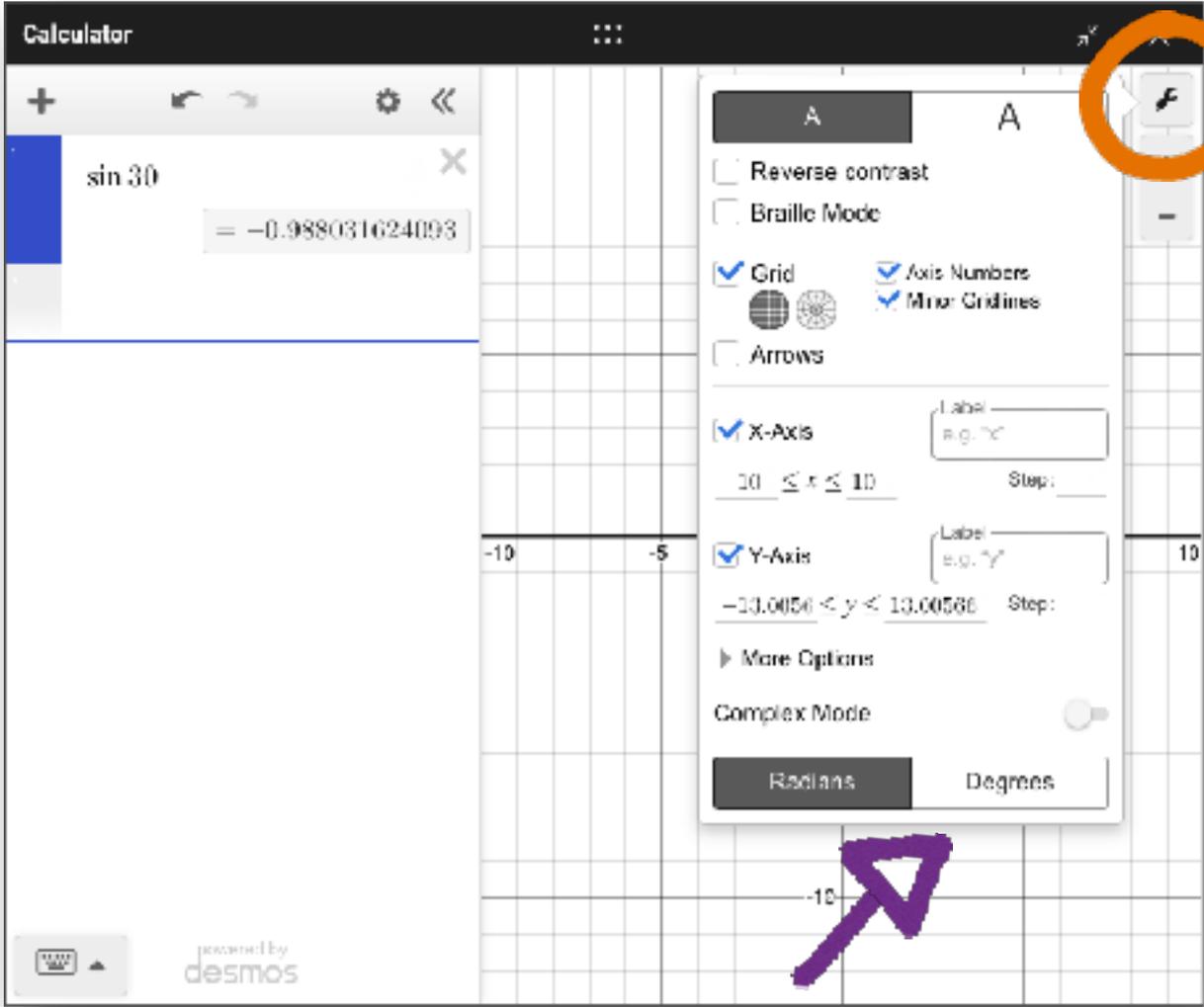
You can go back and forth between questions in this section until time expires. The clock will turn red when 5 minutes remain—**the proctor will not give you any time updates or warnings.**

Close

Built-in Desmos Graphing Calculator
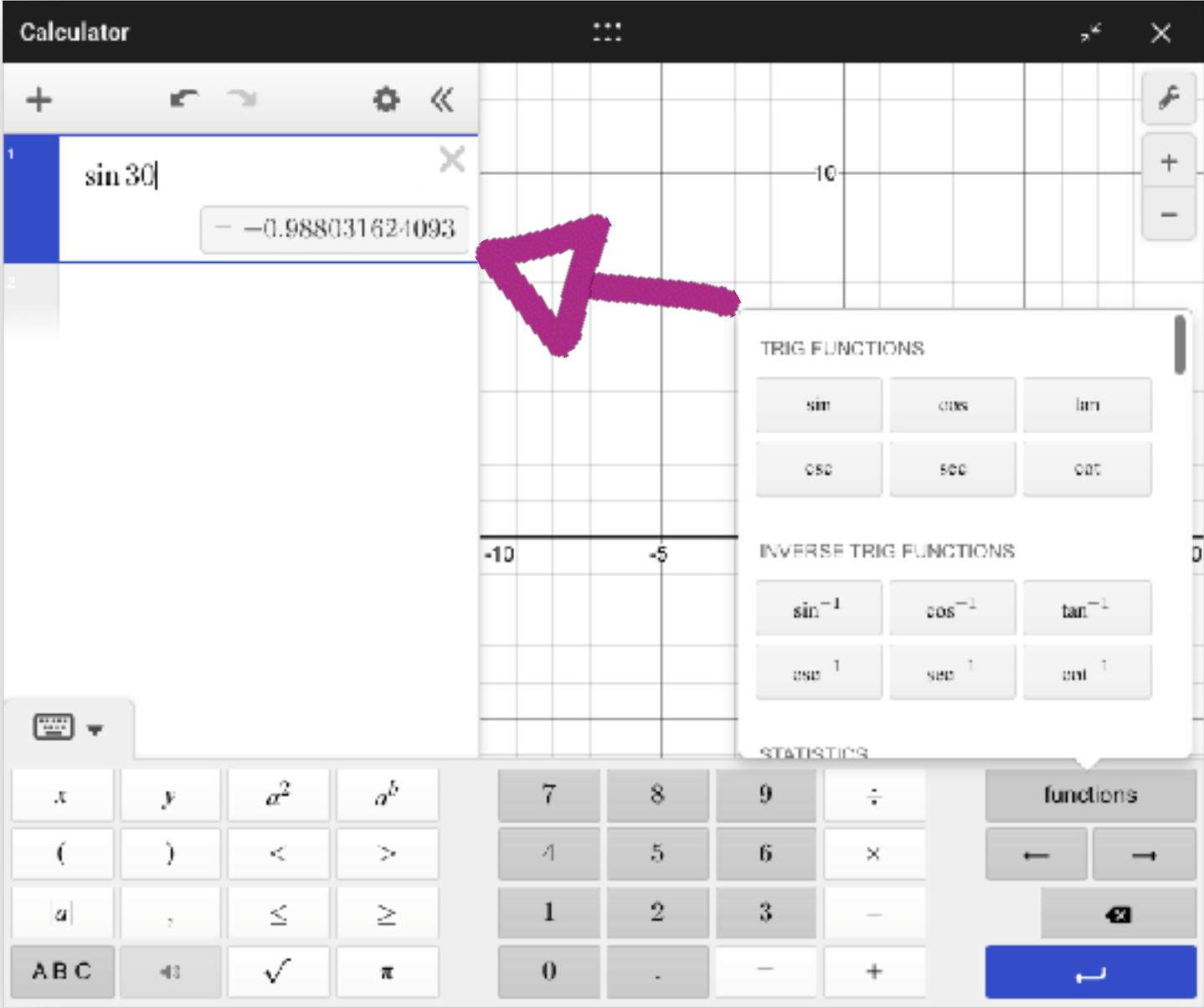
Switching Angle Modes in Desmos!!

Strikethrough to help narrow down options!

9 🔖 **Mark for Review**

Which of the following is most nearly the MOMENTUM of Block B after the collision?

Ⓐ ~~2.0 kg·m/s~~   Undo

Ⓑ ~~3.0 kg·m/s~~   Undo

Ⓒ 4.0 kg·m/s

Ⓓ 6.0 kg·m/s

Highlights & Notes

Highlights & Notes   Calculator   Reference   More

EVIEW

two-block-spring system 🗑

Type of System

Block A is held at rest 🗑

Initial velocity = 0

10   🔖 Mark for Review

two-block-spring system change, if at all, from when Block A is held at rest to when the blocks return to rest?

(A)

Two-Block-Spring System	Two-Block-Spring-Earth System

Line Reader

Section I

Directions ⌄

0:00

Hide

✎ 🗒
Highlights & Notes

🖩
Calculator

𝒙²
Reference

⋮
More

100% 🔋

⋮⋮⋮   ⤢   ✕

ST PREVIEW

⊡

Blocks A and B, of masses m_A and m_B, respectively, are at rest on a horizontal surface with negligible friction. Block A is attached to the table. Block C of mass m_C is suspended by a string that is tied to Block B and passes over a pulley as shown. The blocks all

Attachment
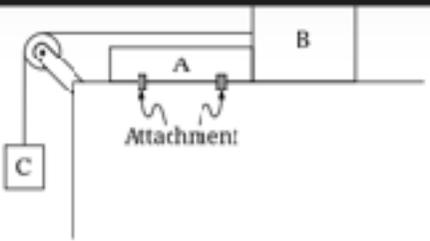
1 🔖 Mark for Review

Which of the following
force exerted by Block

(A) $m_B g$

(B) $m_C g$

(C) $\dfrac{m_A m_C g}{m_A + m_B}$

(D) $\dfrac{m_B m_C g}{m_A + m_B}$

⌐? Help

▦ Shortcuts

👤 Assistive Technology

≡ Line Reader

🏃 Unscheduled Break

⚠ Exit the Exam

Section I Questions Review

Some students have determined the gravitational mass of an object and want to compare it to the object's inertial mass. Procedures that would allow them to accomplish this include which of the following? Select two answers.

(A) Hanging the object vertically from a spring scale and recording the scale reading

(B) Placing the object on one side of a double pan balance, adding objects of known mass to the other side until the masses are balanced, and recording the amount of mass added

(C) Attaching the object to a spring of known spring constant, allowing it to oscillate horizontally on a nearly frictionless surface, and measuring the period

(D) Attaching the object to a force sensor, using the sensor to pull the object across a nearly frictionless horizontal surface, and measuring the acceleration

P1: Table of Information

CONSTANTS AND CONVERSION FACTORS

Universal gravitational constant, $G = 6.67 \times 10^{-11}\ \text{m}^3/(\text{kg} \cdot \text{s}^2) = 6.67 \times 10^{-11}\ \text{N} \cdot \text{m}^2/\text{kg}^2$	Acceleration due to gravity at Earth's surface, $g = 9.8\ \text{m/s}^2$
1 atmosphere of pressure, $1\ \text{atm} = 1.0 \times 10^5\ \text{N}/\text{m}^2 = 1.0 \times 10^5\ \text{Pa}$	Magnitude of the gravitational field strength at the Earth's surface, $g = 9.8\ \text{N/kg}$

PREFIXES

Factor	Prefix	Symbol
10^{12}	tera	T
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

UNIT SYMBOLS

hertz,	Hz	newton,	N
joule,	J	pascal,	Pa
kilogram,	kg	second,	s
meter,	m	watt,	W

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES

θ	$0°$	$30°$	$37°$	$45°$	$53°$	$60°$	$90°$
$\sin\theta$	0	$1/2$	$3/5$	$\sqrt{2}/2$	$4/5$	$\sqrt{3}/2$	1
$\cos\theta$	1	$\sqrt{3}/2$	$4/5$	$\sqrt{2}/2$	$3/5$	$1/2$	0
$\tan\theta$	0	$\sqrt{3}/3$	$3/4$	1	$4/3$	$\sqrt{3}$	∞

The following conventions are used in this exam:
- The frame of reference of any problem is assumed to be inertial unless otherwise stated.
- Air resistance is assumed to be negligible unless otherwise stated.
- Springs and strings are assumed to be ideal unless otherwise stated.
- Fluids are assumed to be ideal, and pipes are assumed to be completely filled by fluid, unless otherwise stated.

GEOMETRY AND TRIGONOMETRY

Rectangle	Rectangular Solid
$A = bh$	$V = \ell wh$

Triangle	Cylinder
$A = \dfrac{1}{2}bh$	$V = \pi r^2 \ell$
	$S = 2\pi r \ell + 2\pi r^2$

Circle	Sphere
$A = \pi r^2$	$V = \dfrac{4}{3}\pi r^3$
$C = 2\pi r$	$S = 4\pi r^2$
$s = r\theta$	

A = area
b = base
C = circumference
h = height
ℓ = length
r = radius
s = arc length
S = surface area
V = volume
w = width
θ = angle

Right Triangle

$a^2 + b^2 = c^2$

$\sin\theta = \dfrac{a}{c}$

$\cos\theta = \dfrac{b}{c}$

$\tan\theta = \dfrac{a}{b}$

P2: Table of Information

CONSTANTS AND CONVERSION FACTORS

Avogadro's number,	$N_0 = 6.02 \times 10^{23}$ mol^{-1}
Universal gas constant,	$R = 8.31$ J/(mol·K)
Boltzmann's constant,	$k_B = 1.38 \times 10^{-23}$ J/K
1 atmosphere of pressure,	1 atm $= 1.0 \times 10^5$ N/m$^2 = 1.0 \times 10^5$ Pa
Coulomb's constant,	$k = \dfrac{1}{4\pi\varepsilon_0} = 9.0 \times 10^9 \ \dfrac{\text{N} \cdot \text{m}^2}{\text{C}^2}$
Proton mass,	$m_p = 1.67 \times 10^{-27}$ kg
Neutron mass,	$m_n = 1.67 \times 10^{-27}$ kg
Electron mass,	$m_e = 9.11 \times 10^{-31}$ kg
Elementary charge,	$e = 1.60 \times 10^{-19}$ C
Vacuum permittivity,	$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/(N·m^2)
Vacuum permeability,	$\mu_0 = 4\pi \times 10^{-7}$ (T·m)/A
1 electron volt,	1 eV $= 1.60 \times 10^{-19}$ J
Planck's constant,	$h = 6.63 \times 10^{-34}$ J·s $= 4.14 \times 10^{-15}$ eV·s
	$hc = 1.99 \times 10^{-25}$ J·m $= 1240$ eV·nm
Speed of light,	$c = 3.00 \times 10^8$ m/s
Wien's constant,	$b = 2.90 \times 10^{-3}$ m·K
Stefan-Boltzmann constant,	$\sigma = 5.67 \times 10^{-8}$ W/(m^2·K^4)
1 unified atomic mass unit,	1 u $= 1.66 \times 10^{-27}$ kg $= 931$ MeV/c^2

Universal gravitational constant, $G = 6.67 \times 10^{-11}$ m^3/(kg·s^2) $= 6.67 \times 10^{-11}$ N·m^2/kg^2

Magnitude of the acceleration due to gravity at Earth's surface, $g = 9.8$ m/s^2

Magnitude of the gravitational field strength at the Earth's surface, $g = 9.8$ N/kg

UNIT SYMBOLS

ampere,	A
coulomb,	C
degree Celsius,	°C
electron volt,	eV
farad,	F
hertz,	Hz
joule,	J
kelvin,	K
kilogram,	kg
meter,	m
mole,	mol
newton,	N
ohm,	Ω
pascal,	Pa
second,	s
tesla,	T
volt,	V
watt,	W

PREFIXES

Factor	Prefix	Symbol
10^{12}	tera	T
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES

θ	0°	30°	37°	45°	53°	60°	90°
$\sin\theta$	0	1/2	3/5	$\sqrt{2}/2$	4/5	$\sqrt{3}/2$	1
$\cos\theta$	1	$\sqrt{3}/2$	4/5	$\sqrt{2}/2$	3/5	1/2	0
$\tan\theta$	0	$\sqrt{3}/3$	3/4	1	4/3	$\sqrt{3}$	∞

The following conventions are used in this exam:

- The frame of reference of any problem is assumed to be inertial unless otherwise stated.
- Air resistance is assumed to be negligible unless otherwise stated.
- Springs and strings are assumed to be ideal unless otherwise stated.
- The electric potential is zero at an infinite distance from an isolated point charge.
- The direction of current is the direction in which positive charges would drift.
- All batteries, wires, and meters are assumed to be ideal unless otherwise stated.

P1: Table of Information Conventions

The following conventions are used in this exam:

- The frame of reference of any problem is assumed to be inertial unless otherwise stated.
- Air resistance is assumed to be negligible unless otherwise stated.
- Springs and strings are assumed to be ideal unless otherwise stated.
- Fluids are assumed to be ideal, and pipes are assumed to be completely filled by fluid, unless otherwise stated.

P2: Table of Information Conventions

The following conventions are used in this exam:

- The frame of reference of any problem is assumed to be inertial unless otherwise stated.

- Air resistance is assumed to be negligible unless otherwise stated.

- Springs and strings are assumed to be ideal unless otherwise stated.

- The electric potential is zero at an infinite distance from an isolated point charge.

- The direction of current is the direction in which positive charges would drift.

- All batteries, wires, and meters are assumed to be ideal unless otherwise stated.

Developing the Science Practices

How your students will be asked to demonstrate **what** they know

Science Practice/Skills

Practice 1	**Practice 2**	**Practice 3**
Creating Representations 1	*Mathematical Routines* 2	*Scientific Questioning and Argumentation* 3
Create representations that depict physical phenomena.	Conduct analyses to derive, calculate, estimate, or predict.	Describe experimental procedures, analyze data, and support claims.

SKILLS

1.A Create diagrams, tables, charts, or schematics to represent physical situations.	**2.A** Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway.	**3.A** Create experimental procedures that are appropriate for a given scientific question.
1.B Create quantitative graphs with appropriate scales and units, including plotting data.	**2.B** Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway.	**3.B** Apply an appropriate law, definition, theoretical relationship, or model to make a claim.
1.C Create qualitative sketches of graphs that represent features of a model or the behavior of a physical system.	**2.C** Compare physical quantities between two or more scenarios or at different times and locations in a single scenario.	**3.C** Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.
	2.D Predict new values or factors of change of physical quantities using functional dependence between variables.	

ALL Skills Assessed on the FRQ Section

38

Science Practice/Skills

Practice 1	**Practice 2**	**Practice 3**
Creating Representations **1**	*Mathematical Routines* **2**	*Scientific Questioning and Argumentation* **3**
Create representations that depict physical phenomena.	Conduct analyses to derive, calculate, estimate, or predict.	Describe experimental procedures, analyze data, and support claims.

SKILLS

1.A Create diagrams, tables, charts, or schematics to represent physical situations.	**2.A** Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway.	**3.A** Create experimental procedures that are appropriate for a given scientific question.
1.B Create quantitative graphs with appropriate scales and units, including plotting data.	**2.B** Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway.	**3.B** Apply an appropriate law, definition, theoretical relationship, or model to make a claim.
1.C Create qualitative sketches of graphs that represent features of a model or the behavior of a physical system.	**2.C** Compare physical quantities between two or more scenarios or at different times and locations in a single scenario.	**3.C** Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.
	2.D Predict new values or factors of change of physical quantities using functional dependence between variables.	

ONLY Skills Assessed on the MCQ Section

Science Practice/Skills Weighting: P1 & P2

Skill		Approximate MCQ Exam Weighting	Approximate FR Exam Weighting
1.A	Create diagrams, tables, charts, or schematics to represent physical situations.	N/A	
1.B	Create quantitative graphs with appropriate scales and units, including plotting data.	N/A	20–35%
1.C	Create qualitative sketches of graphs that represent features of a model or the behavior of a physical system.	N/A	
2.A	Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway.	15–20%	
2.B	Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway.	20–25%	30–40%
2.C	Compare physical quantities between two or more scenarios or at different times and locations in a single scenario.	10–15%	
2.D	Predict new values or factors of change of physical quantities using functional dependence between variables.	10–15%	

Skill		Approximate MCQ Exam Weighting	Approximate FR Exam Weighting
3.A	Create experimental procedures that are appropriate for a given scientific question.	N/A	
3.B	Apply an appropriate law, definition, theoretical relationship, or model to make a claim.	20–25%	35–45%
3.C	Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.	5–10%	

AP Physics 1 & 2

Skill		Approximate MCQ Exam Weighting	Approximate FR Exam Weighting
1.A	Create diagrams, tables, charts, or schematics to represent physical situations.	N/A	
1.B	Create quantitative graphs with appropriate scales and units, including plotting data.	N/A	20–35%
1.C	Create qualitative sketches of graphs that represent features of a model or the behavior of a physical system.	N/A	
2.A	Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway.	15–20%	
2.B	Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway.	20–25%	30–40%
2.C	Compare physical quantities between two or more scenarios or at different times and locations in a single scenario.	10–15%	
2.D	Predict new values or factors of change of physical quantities using functional dependence between variables.	10–15%	
2.A	Create experimental procedures that are appropriate for a given scientific question.	N/A	
2.B	Apply an appropriate law, definition, theoretical relationship, or model to make a claim.	20–25%	35–45%
3.C	Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.	5–10%	

AP Physics C: Mech and E&M

Skill		Approximate MCQ Exam Weighting	Approximate FR Exam Weighting
1.A	Create diagrams, tables, charts, or schematics to represent physical situations.	N/A	
1.B	Create quantitative graphs with appropriate scales and units, including plotting data.	N/A	20–35%
1.C	Create qualitative sketches of graphs that represent features of a model or the behavior of a physical system.		
2.A	Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway.	25–30%	
2.B	Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway.	20–25%	40–45%
2.C	Compare physical quantities between two or more scenarios or at different times and locations in a single scenario.	10–15%	
2.D	Predict new values or factors of change of physical quantities using functional dependence between variables.	10–15%	
3.A	Create experimental procedures that are appropriate for a given scientific question.	N/A	
3.B	Apply an appropriate law, definition, theoretical relationship, or model to make a claim.	15–25%	30–35%
3.C	Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.	5–10%	

41

Developing the Science Practices

Throughout the course, students will develop science practices that are fundamental to the discipline of physics. Students will benefit from multiple opportunities to develop these practices in a scaffolded manner. The tables that follow look at each of the science practices and their associated skills and provide examples of questions with sample activities for incorporating instruction on that skill into the course.

Science Practice 1: Creating Representations

Create representations that depict physical phenomena

When physicists describe and explain complex phenomena, they try to simplify real objects, systems, and processes to make the analysis manageable. These simplifications or models are used to predict how new phenomena will occur. A simple model may treat a system as an object, neglecting the system's internal structure and behavior. More complex models are models of a system of objects, such as a firework display or planets orbiting the sun. A process can be simplified, too. Models can be both conceptual and mathematical. The differential equation relating a velocity dependent force exerted on an object to the acceleration of that object is an example of a mathematical model, while the idea of the object reaching a terminal velocity is a conceptual model. To make a good model, students need to identify a set of the most important characteristics of a phenomenon or system that may simplify analysis. They then need to create a representation of those characteristics. Examples of representations used to

model introductory physics concepts are pictures, motion maps, free-body diagrams, force diagrams, graphs, energy bar charts, and momentum charts. Representations help in analyzing phenomena, making predictions and communicating ideas. AP Physics C: Mechanics requires students to use, analyze, and/or re-express models and representations of natural or man-made systems. A special note about free-body diagrams: *AP Physics C: Mechanics only expects students to depict the forces exerted on objects, not the force components on free-body diagrams. On the AP Physics exams, individual forces represented on a free-body diagram must be drawn as individual straight arrows, originating on the dot and pointing in the direction of the force. Individual forces that are exerted in the same direction must be drawn side by side, not overlapping.*

Students often think that to make a graph, they need to connect the data points, or that the best-fit function is always linear. Thus, it is important that they know how to construct a best-fit curve, even for data that do not fit a linear relationship.

The following table provides examples of questions and sample activities for strengthening the skill of creating representations.

Science Practice 1: *Creating Representations*

| Skill	Questions to Ask Students	Sample Activities
1.A Create diagrams, tables, charts, or schematics to represent physical situations.	• What kind of model or representation would be appropriate for this physical scenario? • What physical characteristics can be modeled or represented for this physical scenario? • What features of the representation provide information relevant to the question or problem?	Have students divide their paper into four quarters. In each quarter of the paper, have students create a representation of a provided physical situation. For example, have students create four different representations of two objects during an elastic collision. Representations can include graphs, equations, narratives, bar charts, motion maps, free-body diagrams, or sketches of physical situations. Have students describe the consistency between the representations.
1.B Create quantitative graphs with appropriate scales and units, including plotting data.	• What data should be plotted? • What scale and axis labels should be used? What does an appropriately scaled graph look like? • What does a graph need to contain to be considered "correctly labeled"? • How should the data be graphed so that the best-fit curve shows a relationship? • What do the data on the graph show? • Is there a pattern present in the data? How do you know? What does the pattern show about the relationship between quantities? • What data would need to be graphed to create a linear relationship? • What is the physical meaning of the slope and/or area underneath the linearized graph? • What is the physical meaning of the y and/or x intercepts of the linearized graph?	When learning about one-dimensional motion, have students measure the time it takes for an object to fall a specified height. Repeat the measurements for various heights. Have students determine what they should graph so that they can create a linearized graph. Have students identify correct graphs by giving them a "What, If Anything, Is Wrong?" task. Ask students to analyze a set of data and a supposed matching graph, and ask them to identify what, if anything, is wrong with the graph. The "wrong" things can be simple at first (e.g., scales not uniform, labels left off) and then can be scaffolded to be more difficult and address student misconceptions later in the course.

AP Physics 1 – Skill Based Case Study

A block is released from rest near the top of a rough ramp inclined at an angle θ above the horizontal. Point A is a distance L away from the point where the block is released, as shown in the figure. The coefficient of kinetic friction between the block and the ramp is μ_k. The block is moving with speed v_A when it reaches point A.
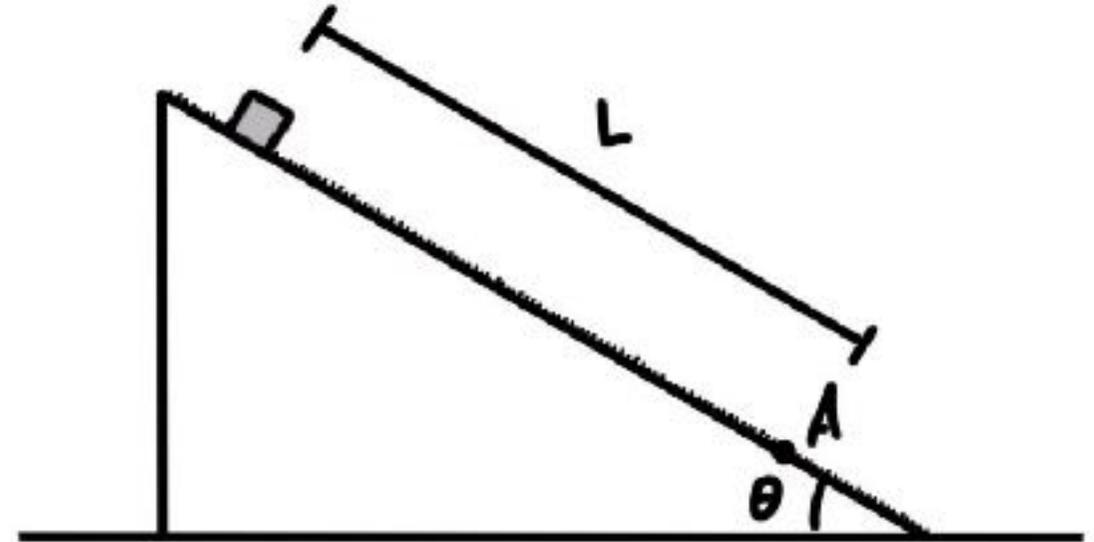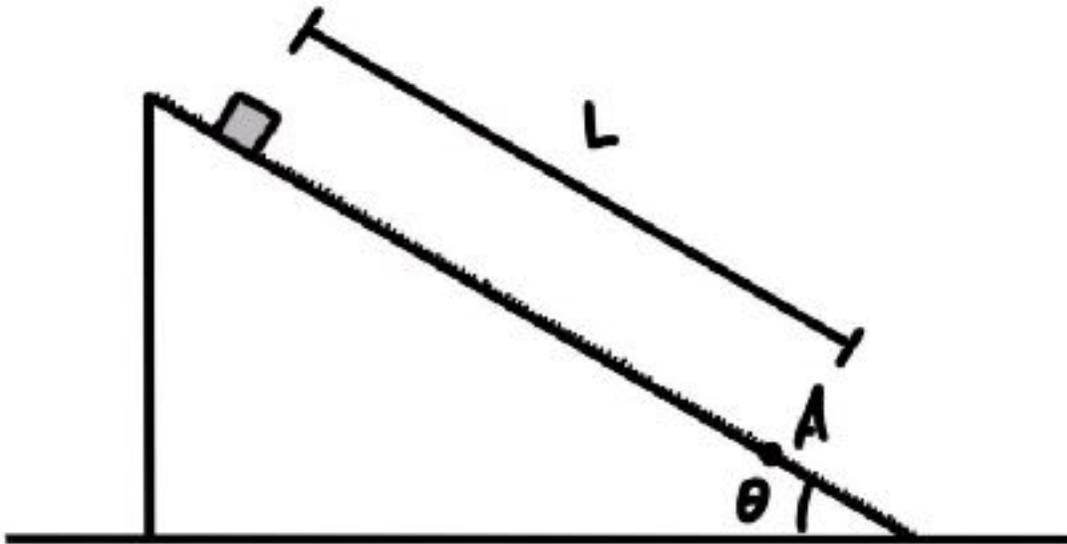
2.A *Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway*

A block is released from rest near the top of a rough ramp inclined at an angle θ above the horizontal. Point A is a distance L away from the point where the block is released, as shown in the figure. The coefficient of kinetic friction between the block and the ramp is μ_k.

The block is moving with speed v_A when it reaches point A.
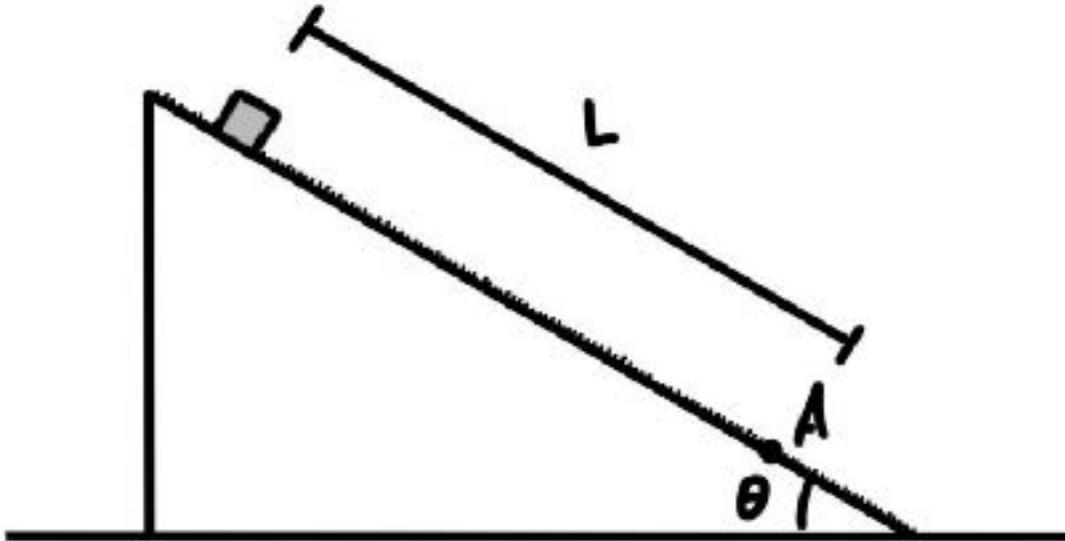
Derive an expression for the speed v_A in terms of the given quantities and physical constants, as appropriate.

(A) $v_A = \sqrt{2gL \sin \theta}$

(B) $v_A = \sqrt{2gL(\sin \theta - \mu_k \cos \theta)}$

(C) $v_A = \sqrt{2gL(\mu_k \cos \theta)}$

(D) $v_A = \sqrt{2gL(\sin \theta + \mu_k \cos \theta)}$

2.B *Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway.*

A block is released from rest near the top of a rough ramp inclined at an angle θ above the horizontal. Point A is a distance L away from the point where the block is released, as shown in the figure. The coefficient of kinetic friction between the block and the ramp is μ_k.

The block is moving with speed v_A when it reaches point A.
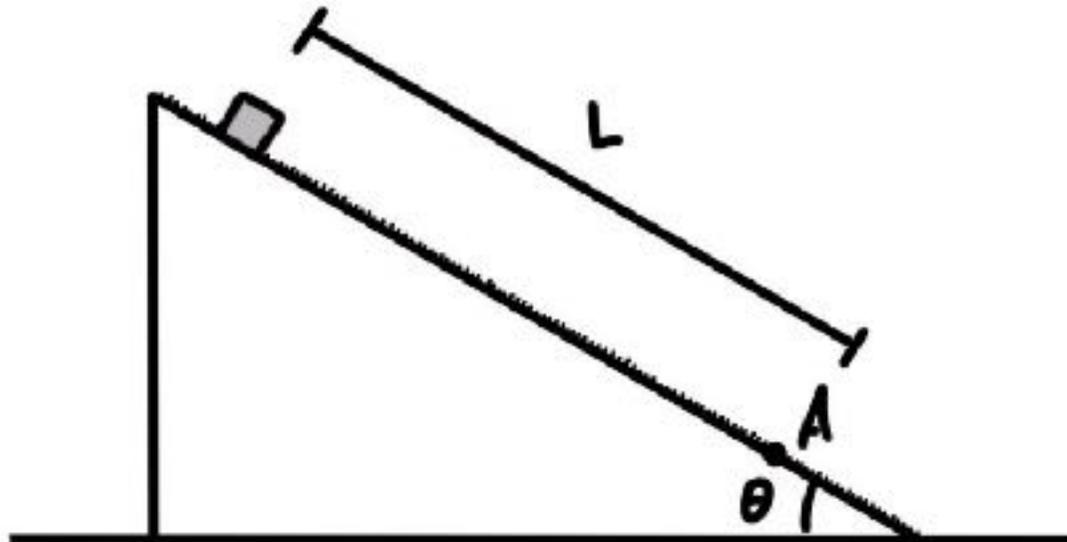
Given $L = 1.0$ m, $\mu_k = 0.1$, and $\theta = 30°$, the speed v_A of the block as it reaches point A is most nearly

(A) 2.9 m/s

(B) 3.1 m/s

(C) 8.3 m/s

(D) 9.9 m/s

A block is released from rest near the top of a rough ramp inclined at an angle θ above the horizontal. Point A is a distance L away from the point where the block is released, as shown in the figure. The coefficient of kinetic friction between the block and the ramp is μ_k.

The block is moving with speed v_A when it reaches point A.

The work done by the force of gravity on the block as the block slides from the point of release to point A is W_1. The angle of the ramp is increased, and the work done by the force of gravity on the block as the block slides from the point of release to point A is W_2. How does W_1 compare to W_2?

(A) $W_1 > W_2$

(B) $W_1 < W_2$

(C) $W_1 = W_2$

(D) W_1 and W_2 cannot be compared without knowing the mass of the block.

2.D *Predict new values or factors of change of physical quantities using functional dependence between variables.*

A block is released from rest near the top of a rough ramp inclined at an angle θ above the horizontal. Point A is a distance L away from the point where the block is released, as shown in the figure. The coefficient of kinetic friction between the block and the ramp is μ_k. The block is moving with speed v_A when it reaches point A.
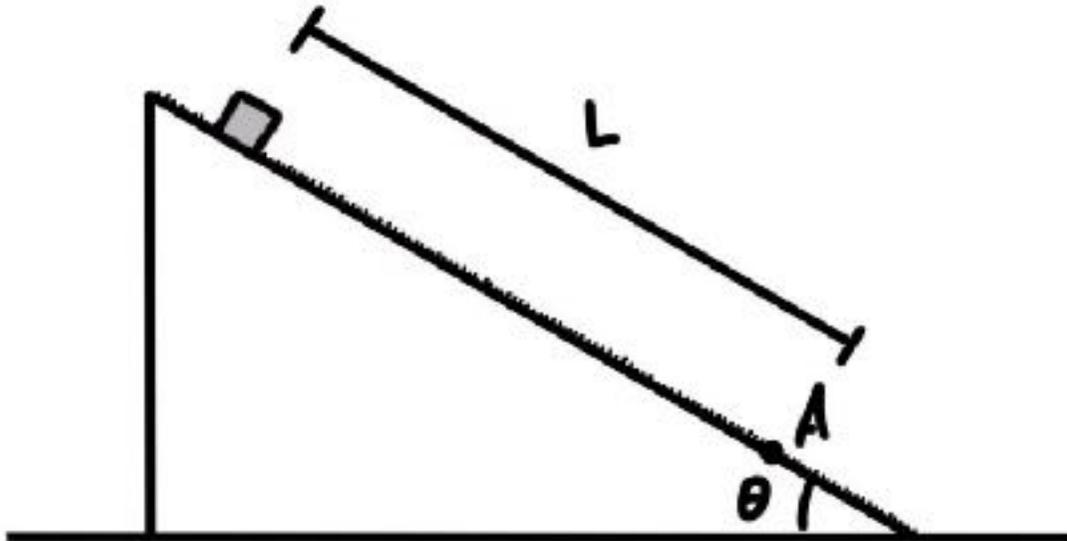
The energy dissipated by the frictional force as the block travels from the point of release to point A is E_1. If the coefficient of friction between the block and the ramp is doubled, the energy dissipated by the frictional force as the block travels from the point of release to point A is E_2. What is the ratio $\dfrac{E_1}{E_2}$?

(A) $\frac{1}{2}$

(B) 1

(C) 2

(D) 4

3.B *Apply an appropriate law, definition, theoretical relationship, or model to make a claim.*

A block is released from rest near the top of a rough ramp inclined at an angle θ above the horizontal. Point A is a distance L away from the point where the block is released, as shown in the figure. The coefficient of kinetic friction between the block and the ramp is μ_k.

The block is moving with speed v_A when it reaches point A.
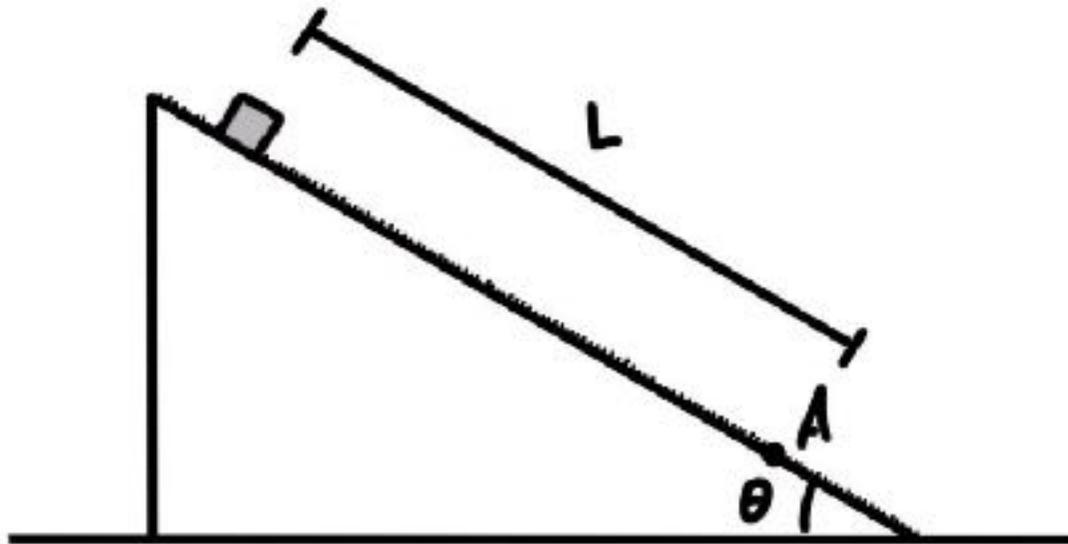
Which of the following statements is correct?

(A) The total mechanical energy of the system consisting of only the block decreases from the time of release until the time when the block reaches point A.

(B) The total mechanical energy of the system consisting of only the block remains constant from the time of release until the time when the block reaches point A.

(C) The total mechanical energy of the system consisting of the block and Earth decreases from the time of release until the time when the block reaches point A.

(D) The total mechanical energy of the system consisting of only the block and Earth remains constant from the time of release until the time when the block reaches point A.

3.C *Support a claim using evidence from experimental data, physical representations, or physical principles or laws.*

A block is released from rest near the top of a rough ramp inclined at an angle θ above the horizontal. Point A is a distance L away from the point where the block is released, as shown in the figure. The coefficient of kinetic friction between the block and the ramp is μ_k.

The block is moving with speed v_A when it reaches point A.
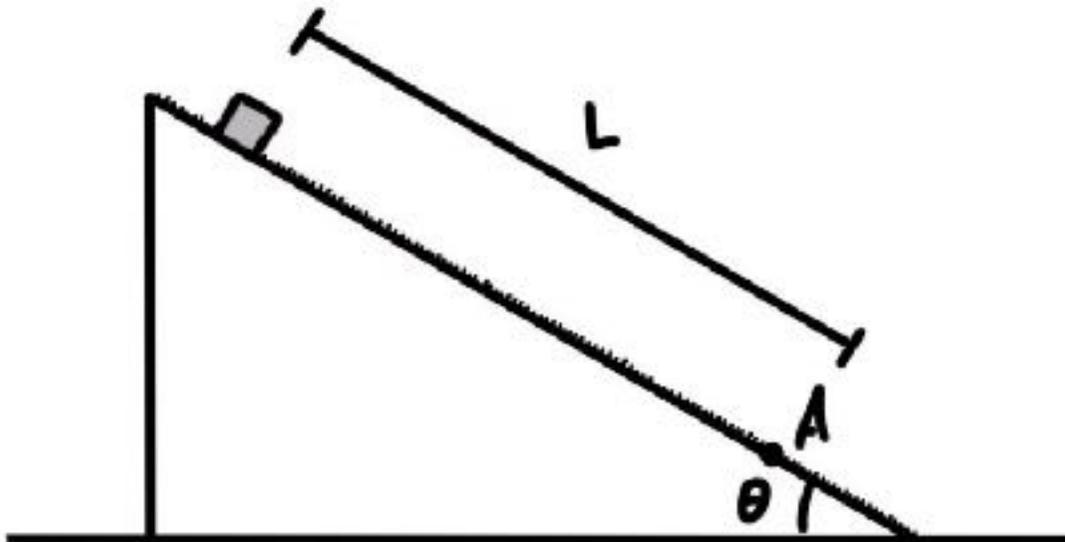
Which of the following statements is a correct justification for the total mechanical energy of the block-Earth system decreasing as the block travels to point A?

(A) The height of the block above the surface of Earth decreases.

(B) The force of friction removes energy from the block-Earth system.

(C) The downward gravitational force exerted on the block by Earth does negative work on the block-Earth system.

(D) The normal force from the incline does negative work on the block-Earth system.

An object *O* is located at point *P* to the left of a converging lens, as shown in the figure. F_1 and F_2 are the focal points of the lens.
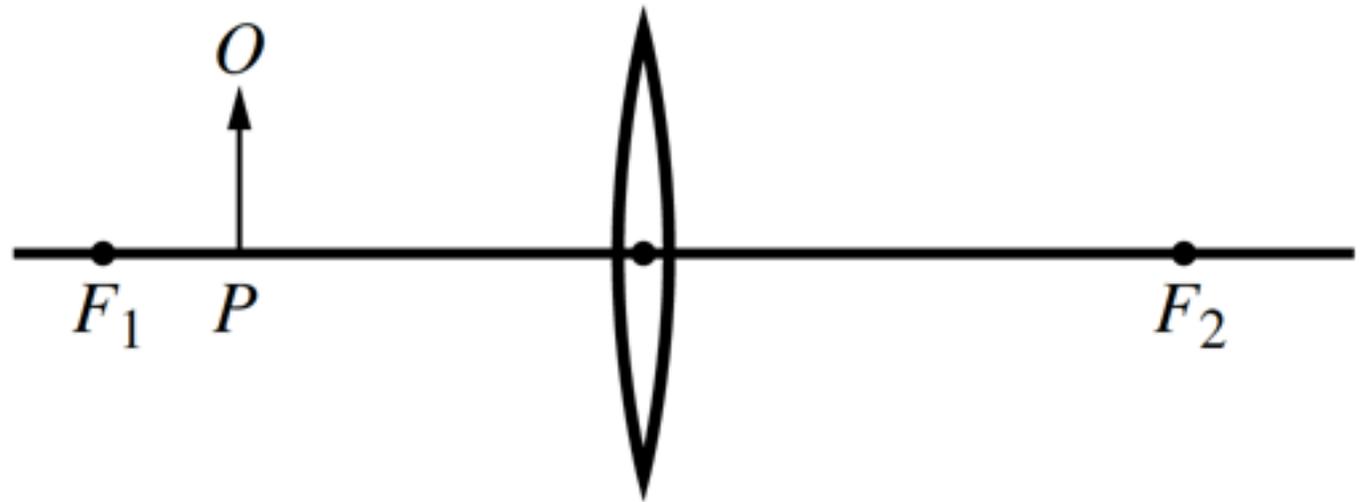
2.A *Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway*

An object O is located at point P to the left of a converging lens, as shown in the figure. F_1 and F_2 are the focal points of the lens.
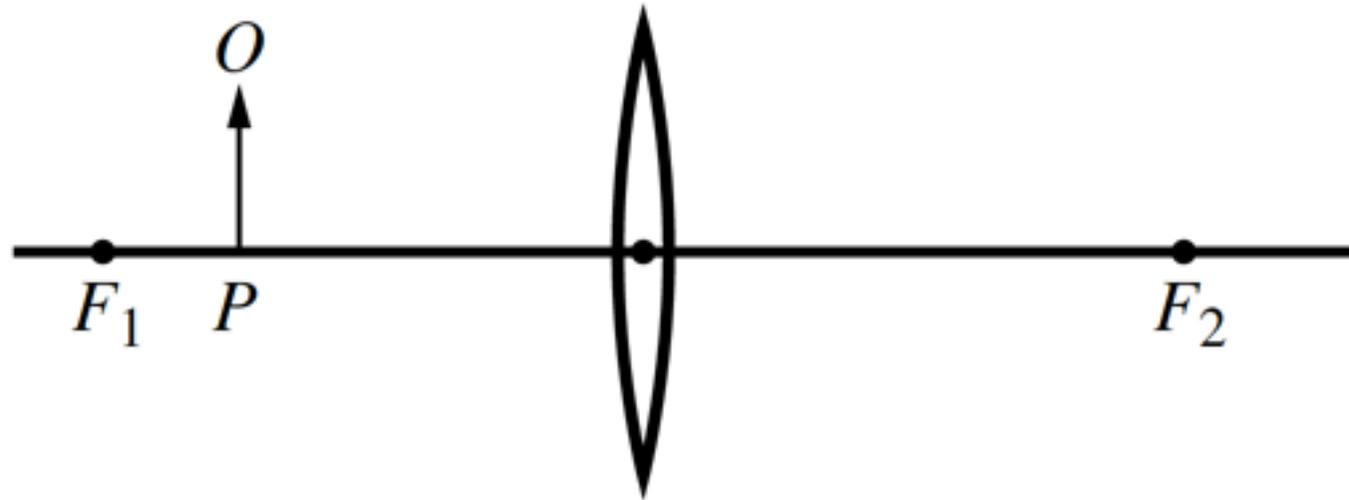
Point P is a distance d_o from the lens, and the focal length of the lens is f. Which of the following is an expression for the magnification of the image?

(A) $\dfrac{f}{d_o - f}$

(B) $\dfrac{d_o - f}{f}$

(C) $\dfrac{fd_o}{d_o - f}$

(D) $\dfrac{d_o - f}{fd_o}$

2.B *Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway.*

An object O is located at point P to the left of a converging lens, as shown in the figure. F_1 and F_2 are the focal points of the lens.
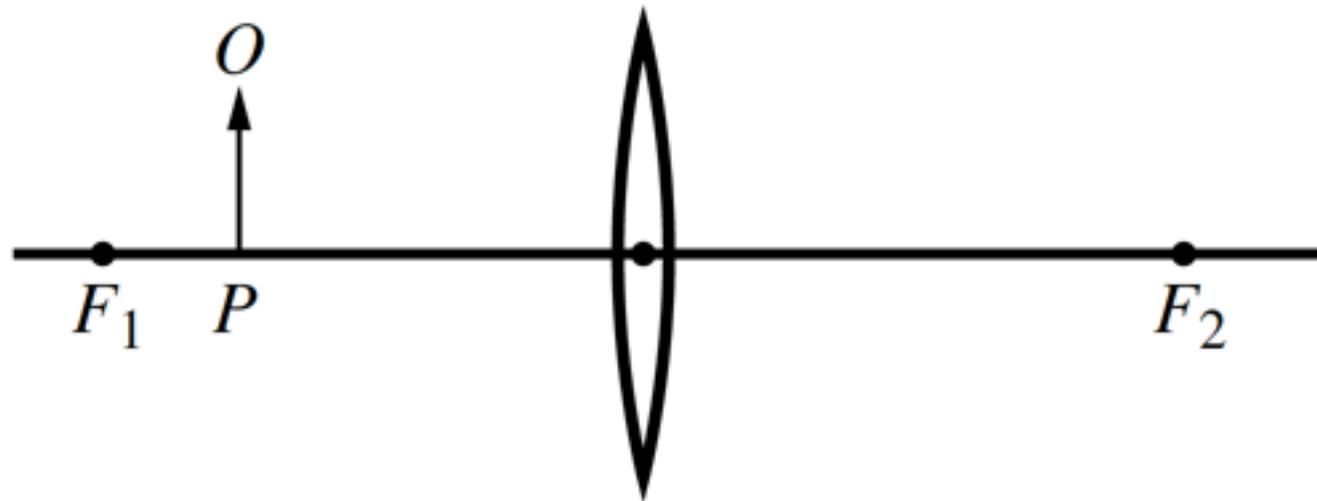
If the focal length of the lens is 0.40 m and point P is 0.30 m to the left of the lens, where is the image of the object located?

(A) 1.2 m to the left of the lens

(B) 0.17 m to the left of the lens

(C) 0.17 m to the right of the lens

(D) 1.2 m to the right of the lens

2.C *Compare physical quantities between two or more scenarios or at different times and/or locations within a single scenario.*

An object O is located at point P to the left of a converging lens, as shown in the figure. F_1 and F_2 are the focal points of the lens.
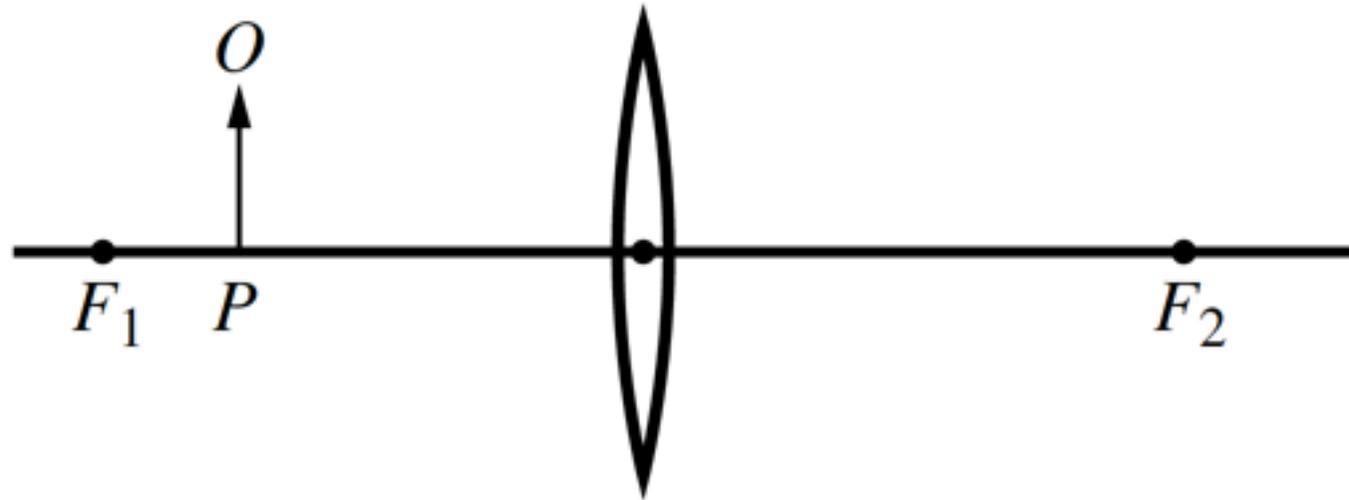
The height of the image, when the object is at point P is H. If the object is moved closer to the lens, how does the new height of the image H_2 compare to H?
(A) $H > H_2$
(B) $H < H_2$
(C) $H = H_2$
(D) H and H_2 cannot be compared without knowing the focal length of the lens.

2.D *Predict new values or factors of change of physical quantities using functional dependence between variables.*

An object O is located at point P to the left of a converging lens, as shown in the figure. F_1 and F_2 are the focal points of the lens.
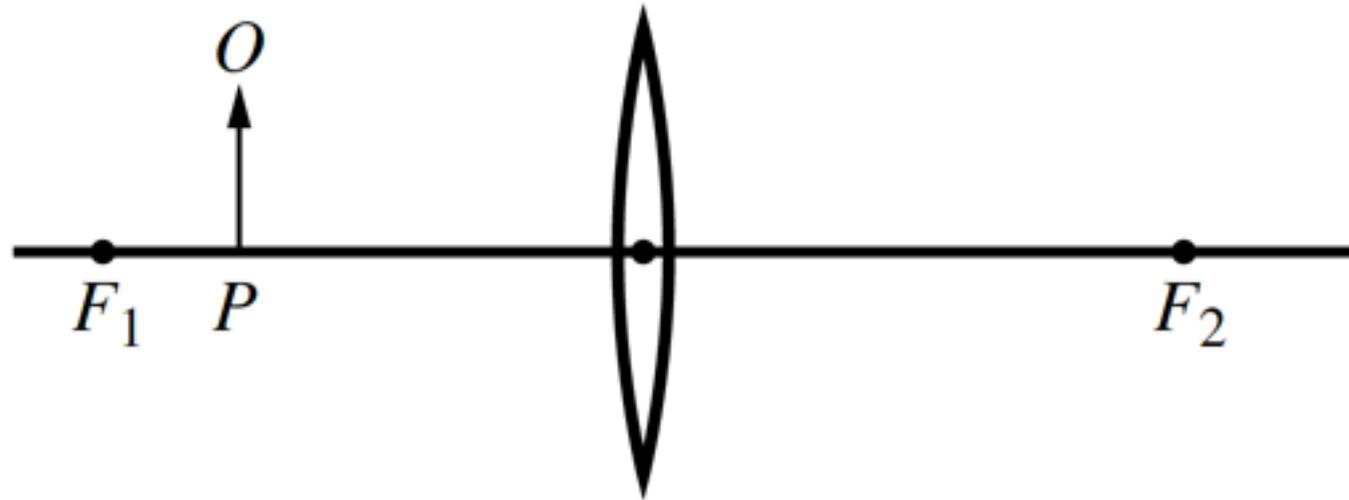
Students move the object to various positions to the left of F_1 and record the image distance and the object distance for each position of the object. Students graph the inverse of the image distance on the vertical axis and the inverse of the object distance on the horizontal axis. Which of the following describes how students can determine a value for the focal length of the lens with their graph?

(A) The focal length is the slope of the graph.
(B) The focal length is the inverse of the slope of the graph.
(C) The focal length is the area bound by the line of best fit and the horizontal axis.
(D) The focal length is the vertical intercept.

3.B *Apply an appropriate law, definition, theoretical relationship, or model to make a claim.*

An object O is located at point P to the left of a converging lens, as shown in the figure. F_1 and F_2 are the focal points of the lens.
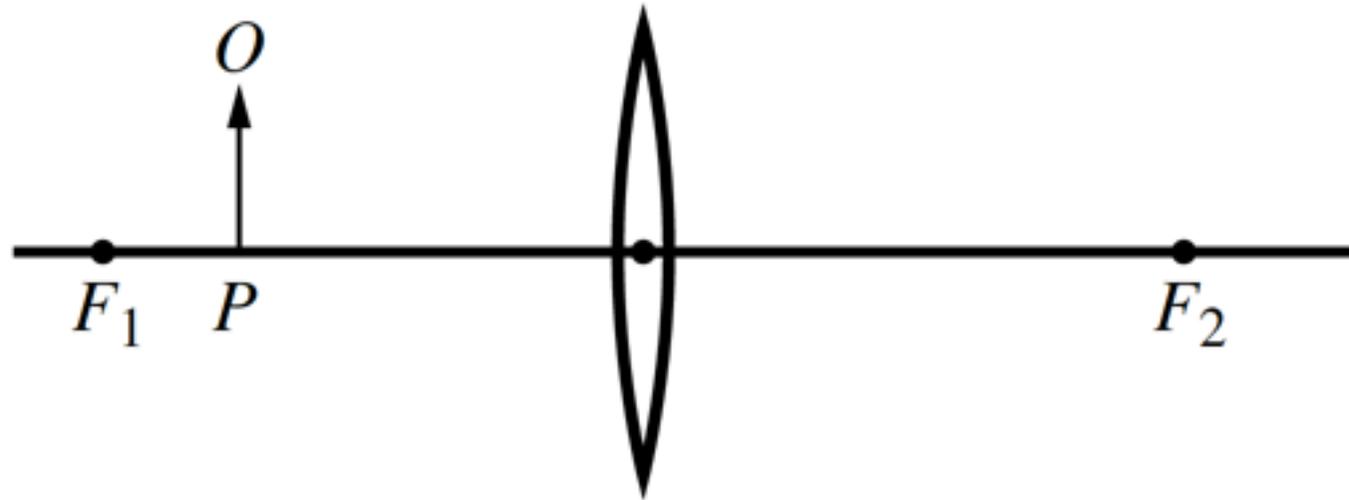
Which of the following characterizes the image when the object is at point P?

(A) Real, inverted, and smaller than the object

(B) Real, upright, and larger than the object

(C) Virtual, upright, and larger than the object

(D) Virtual, upright, and smaller than the object

3.C *Support a claim using evidence from experimental data, physical representations, or physical principles or laws.*

An object O is located at point P to the left of a converging lens, as shown in the figure. F_1 and F_2 are the focal points of the lens.
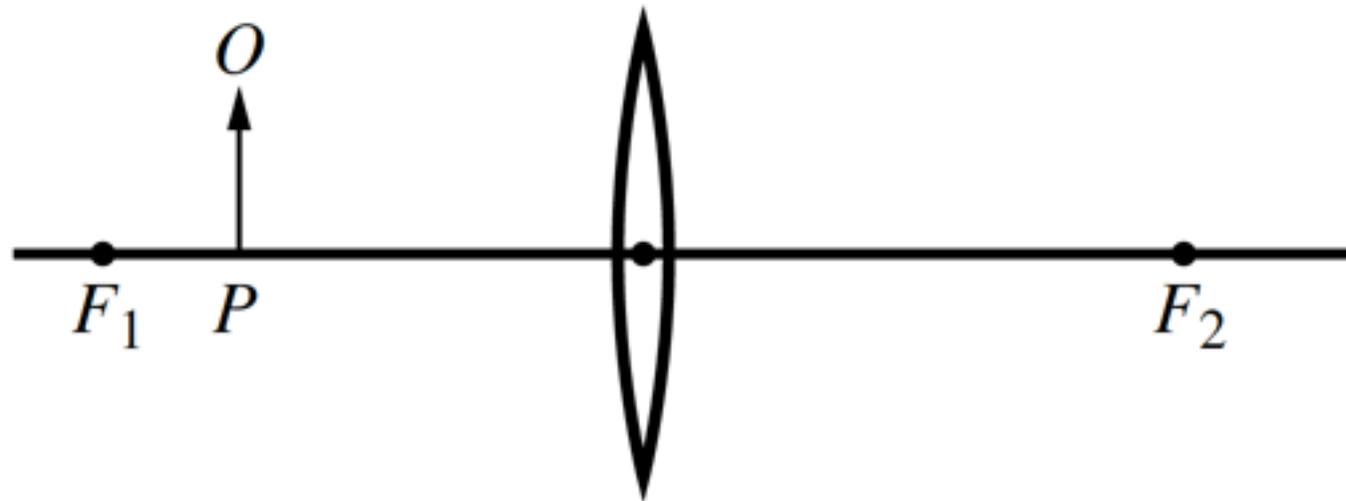
For the setup above where the object distance is less than the focal length of the lens, which of the following correctly explains why the image is virtual?

(A) The light rays originating from the tip of the object are refracted so that they intersect at another common point.

(B) The light rays originating from the tip of the object are refracted so that they diverge such that they appear to have originated from a common point.

(C) The light rays originating from the tip of the object are reflected beyond a critical angle of incidence.

(D) The light rays originating from the tip of the object are reflected and diverge as if they originated from a focal point on the incident side of the lens.

Identify the Science Practice

- Course and Exam Description

  - P1 page 183

  - P2 page 195

- Identify which Science Practice is assessed in each of the Multiple Choice Questions

- Write them down and after you are done check if you are right

Science Practice/Skills

Practice 1	**Practice 2**	**Practice 3**
Creating Representations **1** Create representations that depict physical phenomena.	*Mathematical Routines* **2** Conduct analyses to derive, calculate, estimate, or predict.	*Scientific Questioning and Argumentation* **3** Describe experimental procedures, analyze data, and support claims.

SKILLS

1.A Create diagrams, tables, charts, or schematics to represent physical situations. **1.B** Create quantitative graphs with appropriate scales and units, including plotting data. **1.C** Create qualitative sketches of graphs that represent features of a model or the behavior of a physical system.	**2.A** Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway. **2.B** Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway. **2.C** Compare physical quantities between two or more scenarios or at different times and locations in a single scenario. **2.D** Predict new values or factors of change of physical quantities using functional dependence between variables.	**3.A** Create experimental procedures that are appropriate for a given scientific question. **3.B** Apply an appropriate law, definition, theoretical relationship, or model to make a claim. **3.C** Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.

ONLY Skills Assessed on the MCQ Section

58

AP Physics
Courses Overview

Since Fall 2024

College Major Semester	Engineering, Science, Math, Computer Science	Pre-Med and other
1st	AP Physics C: Mechanics	AP Physics 1
2nd	AP Physics C: E&M	AP Physics 2

AP Physics 1
Course Overview
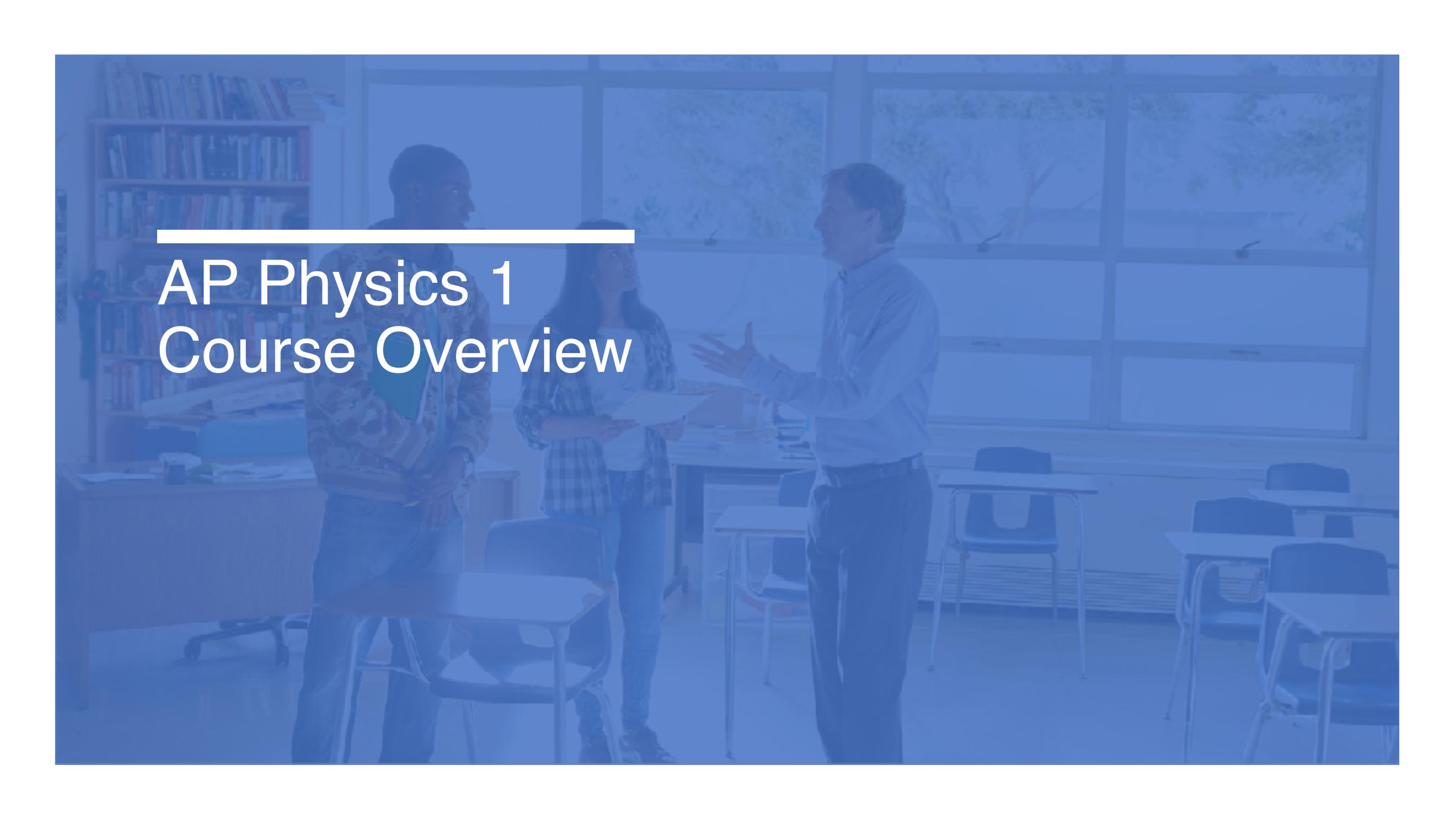
P1 Units: May 2025

Algebra Based course meant to replicate 1st Semester College Physics.

Designed as year long course.

Unit Number	Unit Title
1	Kinematics
2	Force and Translational Dynamics
3	Work, Energy, and Power
4	Linear Momentum
5	Torque and Rotational Dynamics
6	Energy and Momentum of Rotating Systems
7	Oscillations
8	Fluids

AP Physics 1

Old

Unit of Instruction	Exam Weighting
Unit 1: Kinematics	**12–18%**
Unit 2: Dynamics	**16–20%**
Unit 3: Circular Motion and Gravitation	**6–8%**
Unit 4: Energy	**20–28%**
Unit 5: Momentum	**12–18%**
Unit 6: Simple Harmonic Motion	**4–6%**
Unit 7: Torque and Rotational Motion	**12–18%**

Units of Instruction	Exam Weighting
Unit 1: Kinematics	**10–15%**
Unit 2: Force and Translational Dynamics	**18–23%**
Unit 3: Work, Energy, and Power	**18–23%**
Unit 4: Linear Momentum	**10–15%**
Unit 5: Torque and Rotational Dynamics	**10–15%**
Unit 6: Energy and Momentum of Rotating Systems	**5–8%**
Unit 7: Oscillations	**5–8%**
Unit 8: Fluids	**10–15%**

New

AP Physics 2
Course Overview
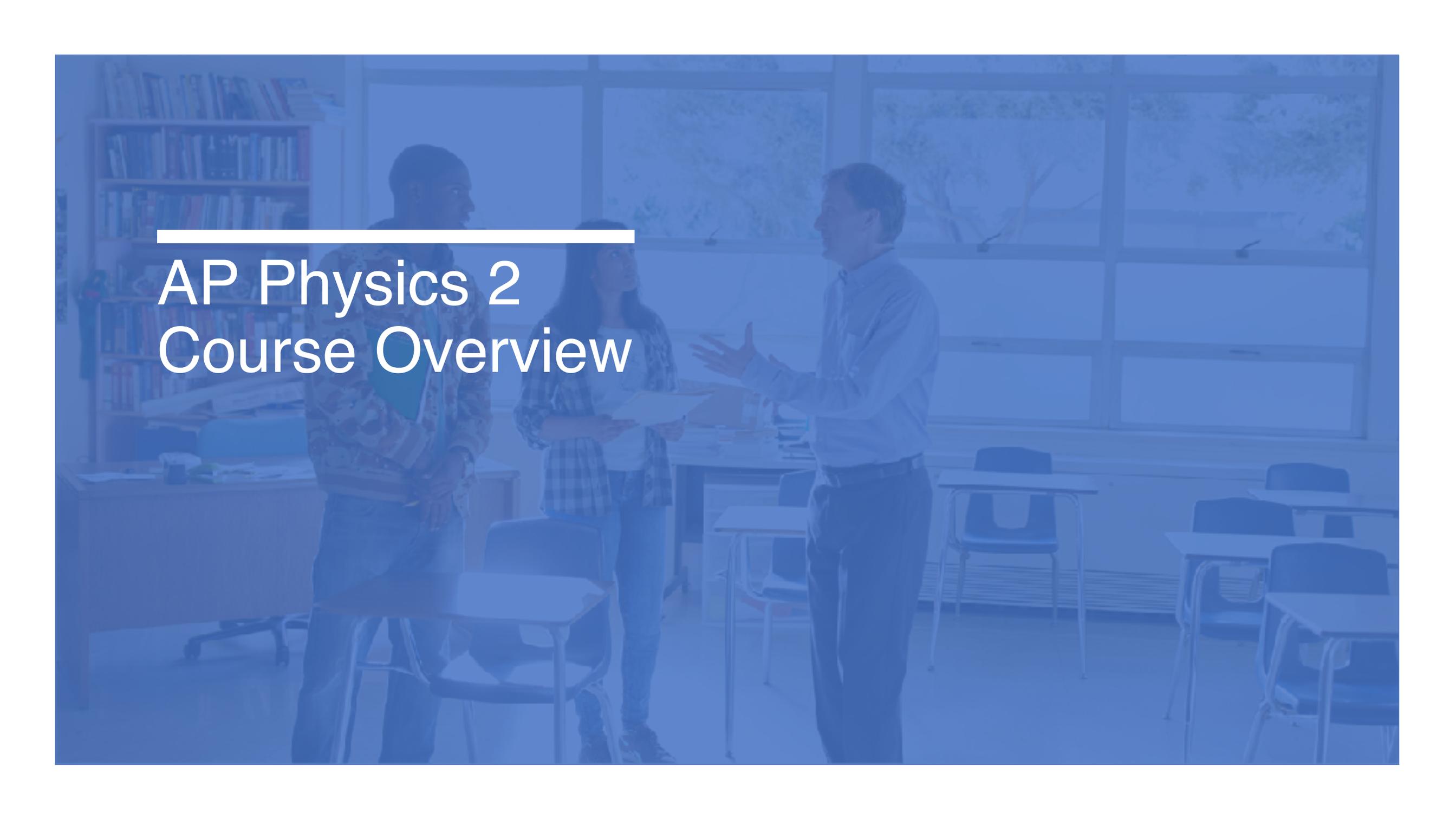
P2 Units: May 2025

Algebra Based course meant to replicate 2nd Semester College Physics.

Designed as year long course.

Unit Number	Unit Title
9	Thermodynamics
10	Electric Force, Field and Potential
11	Electric Circuits
12	Magnetism and Electromagnetism
13	Geometric Optics
14	Waves, Sound and Physical Optics
15	Modern Physics

AP Physics 2

Old

Unit of Instruction	Exam Weighting
Unit 1: Fluids	10–12%
Unit 2: Thermodynamics	12–18%
Unit 3: Electric Force, Field, and Potential	18–22%
Unit 4: Electric Circuits	10–14%
Unit 5: Magnetism and Electromagnetic Induction	10–12%
Unit 6: Geometric and Physical Optics	12–14%
Unit 7: Quantum, Atomic, and Nuclear Physics	10–12%

New

Units of Instruction	Exam Weighting
Unit 9: Thermodynamics	15–18%
Unit 10: Electric Force, Field, and Potential	15–18%
Unit 11: Electric Circuits	15–18%
Unit 12: Magnetism and Electromagnetism	12–15%
Unit 13: Geometric Optics	12–15%
Unit 14: Waves, Sound, and Physical Optics	12–15%
Unit 15: Modern Physics	12–15%

AP Physics C: Mechanics Course Overview
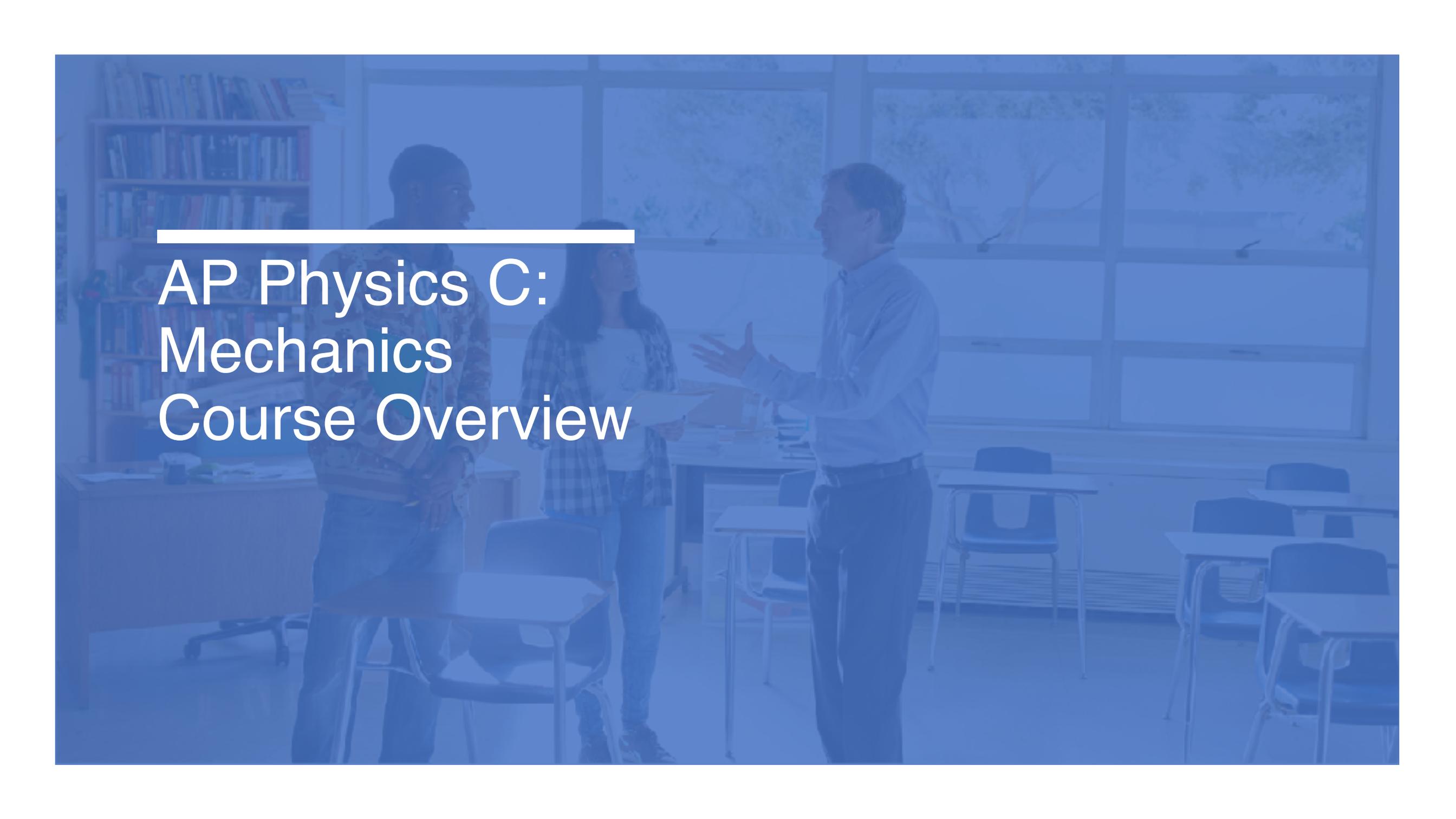
C: Mechanics Units: May 2025

Calculus Based course meant to replicate 1st Semester University Physics.

Can be taught as a semester long course or a year long course.

Unit Number	Unit Title
1	Kinematics
2	Force and Translational Dynamics
3	Work, Energy, and Power
4	Linear Momentum
5	Torque and Rotational Dynamics
6	Energy and Momentum of Rotating Systems
7	Oscillations

AP Physics C: Mechanics

Unit of Instruction	Weighting
Unit 1: Kinematics	14–20%
Unit 2: Newton's Laws of Motion	17–23%
Unit 3: Work, Energy, and Power	14–17%
Unit 4: Systems of Particles and Linear Momentum	14–17%
Unit 5: Rotation	14–20%
Unit 6: Oscillations	6–14%
Unit 7: Gravitation	6–14%

New
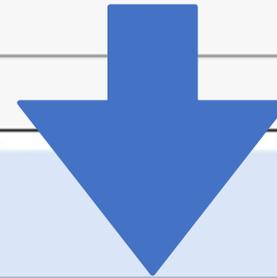
Units of Instruction	Weighting
Unit 1: Kinematics	10–15%
Unit 2: Force and Translational Dynamics	20–25%
Unit 3: Work, Energy and Power	15–25%
Unit 4: Linear Momentum	10–20%
Unit 5: Torque and Rotational Dynamics	10–15%
Unit 6: Energy and Momentum of Rotating Systems	10–15%
Unit 7: Oscillations	10–15%

AP Physics C:
Electricity & Magnetism
Course Overview

C: E&M Units: May 2025

Calculus Based course meant to replicate 2nd Semester University Physics.

Can be taught as a semester long course or a year long course.

Unit Number	Unit Title
8	Electric Charges, Fields, and Gauss's Law
9	Electric Potential
10	Conductors and Capacitors
11	Electric Circuits
12	Magnetic Fields and Electromagnetism
13	Electromagnetic Induction

AP Physics C: E&M

Unit of Instruction	Weighting
Unit 1: Electrostatics	26–34%
Unit 2: Conductors, Capacitors, Dielectrics	14–17%
Unit 3: Electric Circuits	17–23%
Unit 4: Magnetic Fields	17–23%
Unit 5: Electromagnetism	14–20%

Units of Instruction	Exam Weighting
Unit 8: Electric Charges, Fields, and Gauss's Law	15–25%
Unit 9: Electric Potential	10–20%
Unit 10: Conductors and Capacitors	10–15%
Unit 11: Electric Circuits	15–25%
Unit 12: Magnetic Fields and Electromagnetism	10–20%
Unit 13: Electromagnetic Induction	10–20%

New

Redesign Committee

- Hamza Balci, *Kent State University*
- Suzanne Brahmia, *University of Washington*
- Eric Burkholder, *Stanford University*
- Robert Davis, *Brigham Young University*
- Veronica Ellingson, *Hudson Senior High School*
- Kristin Glover, *Prairie Ridge High School*
- Kathy Harper, *The Ohio State University*
- Mark Hossler, *Landmark Christian School*
- Stefan Jeglinski, *University of North Carolina*
- Kathy Koenig, *University of Cincinnati*
- Kristine Lang*, Colorado College*
- Samuel Lofland*, Rowan University*
- Joe Mancino, *Glastonbury High School*
- Ricardo Markland, *Miami Coral Park Senior High School*
- Dee Dee Messer, *William Mason High School*
- Holley Mosley, *Liberty High School*
- Matt Sckalor*, Great Neck South High School*

- Peter Sheldon, *Randolph College*
- Gay Stewart, *West Virginia University*
- Shelly Strand, *West Fargo High School*
- Oather Strawderman, *Lawrence Free State High School*
- Brian Utter, *University of California Merced*
- Matt Vonk, *University of Wisconsin*

College Board Consultants
- Brian Brown
- Anders Gardestig
- Ann Marie Zolandz
- Angela Jensvold
- Mark Widmer

AP Physics Course and Exam Description

Course and Exam Description : 'CED'

The Course and Exam Description aligns course skills with course content.

Content Instruction

- Instruction should help develop and reinforce long-term takeaways for students, not just mastery of or familiarity with specific concepts or vocabulary definitions.

- Consider what students should remember beyond the completion of the course – that is, what students should *understand* vs. *know.*

Skill Instruction

- Students need explicit instruction and repeated opportunities to practice course skills in different contexts throughout the school year – just because students can apply a skill in Unit 1 doesn't always mean they'll be able to apply it in Unit 3.

- Course skills help students make sense of new situations, giving them the tools they need to be successful on the AP Exam and in sequent courses.

AP Physics
Course and Exam Descriptions

Major Sections:

- Front Section
- Course Framework
- Laboratory Investigations
- Instructional Approaches
- Exam Information
- Scoring Guides
- Appendix

A "one-stop shop" for teachers!!
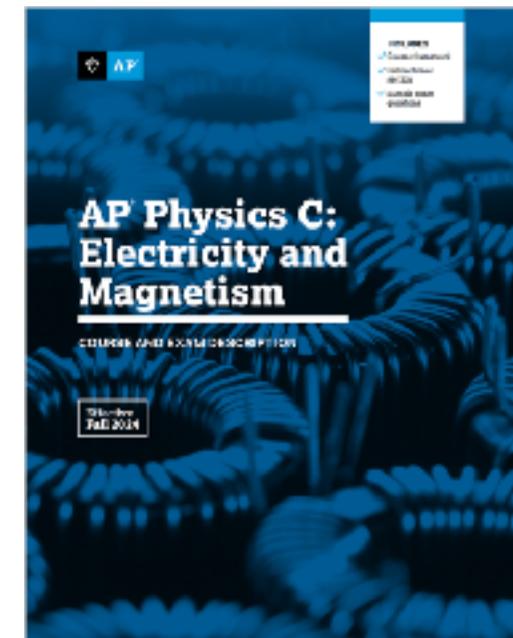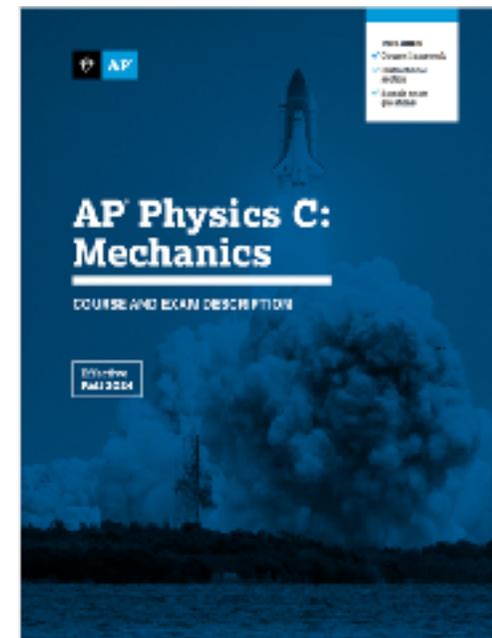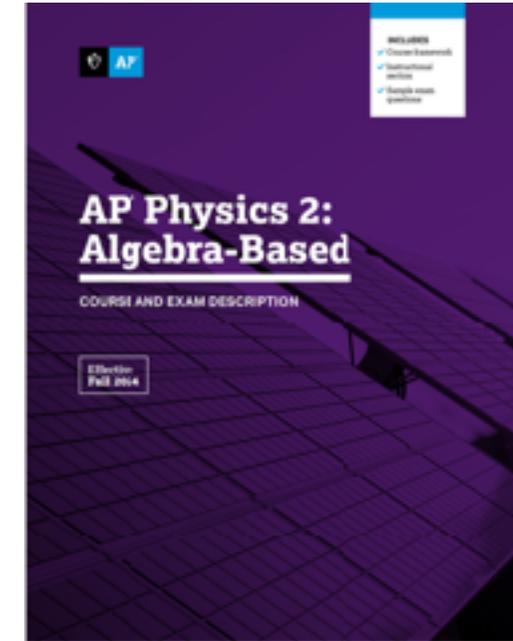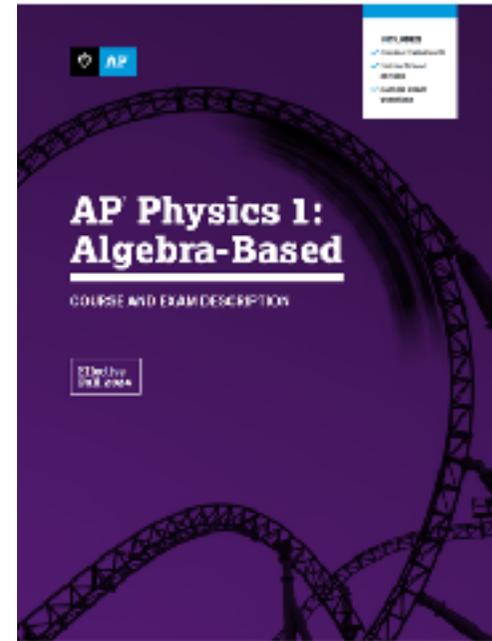
The Course and Exam Description has <u>**six**</u> main sections.

Contents

1. **Front Matter**: All about AP, including resources and supports, as well as course prerequisites and laboratory requirements.

2. **Course Framework**: All course content and skills, with both high-level and detailed views.

3. **Laboratory Investigations**: Information on lab experiments and materials, lab manuals and notebooks, lab time, how to set up a lab program, lab equipment, group collaboration, lab safety, what "counts" as a lab, types and formats of labs, and lab skills.

4. **Instructional Approaches**: Selecting and using course materials, scaffolding scientific inquiry, strategies for constructing learning activities that develop course content and skills, and a case study for practicing apply course skills within the context of a single scenario.

5. **Exam Information**: Overview of the structure and contents of the AP Exam, plus sample exam questions.

6. **Scoring Guidelines**: Explanation of how points are awarded for each FRQ type on the AP Exam

7. **Appendix**: Vocabulary and definitions of important course/discipline ideas, and the reference sheet with equations

Checkpoint 1
What are the three Science Practices and the ten Skills? What do you notice about the skills as you go down the column of a practice?

Checkpoint 2
How many units are there in the AP Physics course? Which unit has the greatest number of topics? How many topics does that unit have?

Checkpoint 7
What are the Generic Lab Equipment items and Physics-Specific Optional Lab Equipment items listed in the Course and Exam Description?

Checkpoint 8
Where can you find more detailed information about teaching and developing the Science Practices?

Checkpoint 6
AP Physics courses require that 25% of instruction time is spent in hans-on laboratory work. How does AP define *Labs* and *Lab Time*?

Checkpoint 3
In the Course at a Glance, what do the percentage ranges under each unit header represent? Why are they given as ranges? Which unit has the greatest percentage listed?

Checkpoint 5
Put these terms in order from most general to most specific content knowledge:
Topic
Learning Objective
Unit
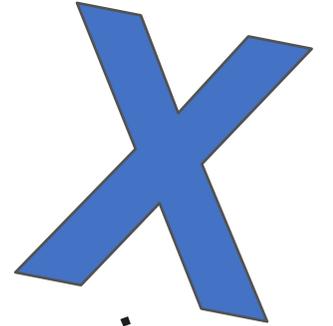Essential Knowledge.

Checkpoint 9
Which skills are assessed on the MCQ section of the exam and which skills are assessed on the FRQ section of the exam?

Checkpoint 4
What information is provided at the beginning of every Unit?

Checkpoint 10
Where can you find the Equation Sheets in the Course and Exam Description? What information are students provided in them?

Textbooks,
Syllabus Development Guides,
Sample Syllabi
And
Yearlong Pacing

2024-2025 Plan

# 2025-26 AP Course Audit Process: AP Physics

Key takeaway: Administrators will be able to renew previously-authorized courses from 24-25, but not from before last year.

Submission Options

1. Adopt the Unit Guides or a Sample Syllabus
2. Claim identical to an approved syllabus (i.e., from a colleague)
3. Submit an original course document

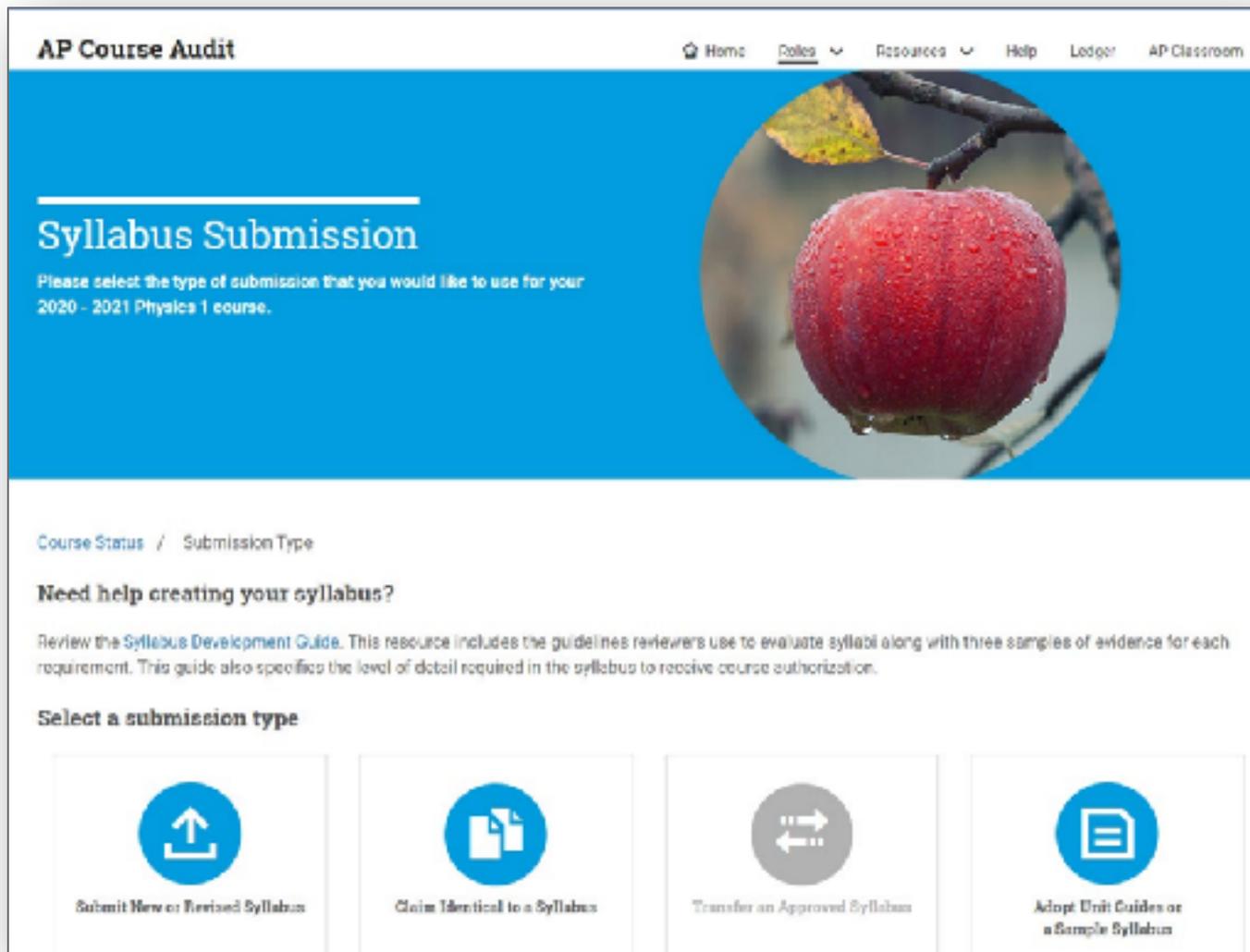All AP Physics teachers **returning from before last year** will have to:

1. Complete the AP Course Audit Form attestation; and
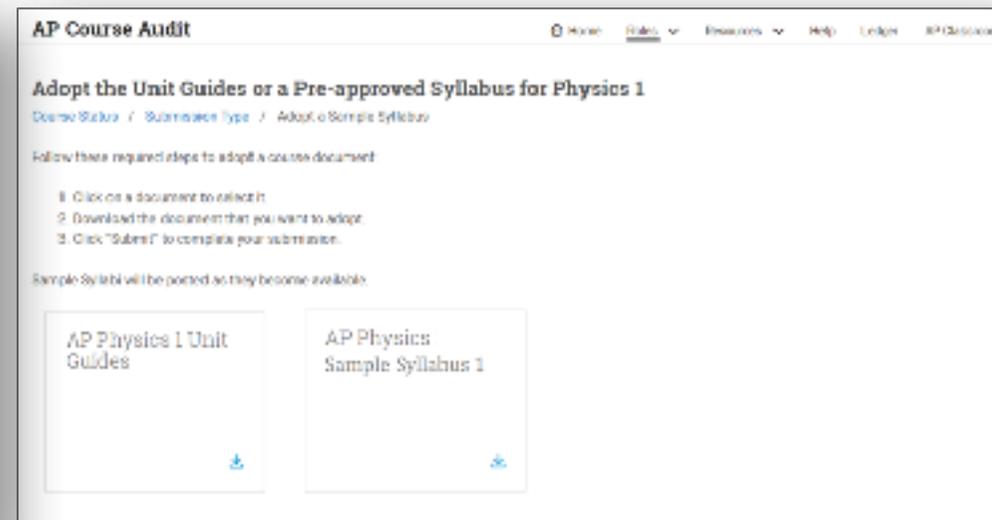2. Select one of the three submission options for authorization.
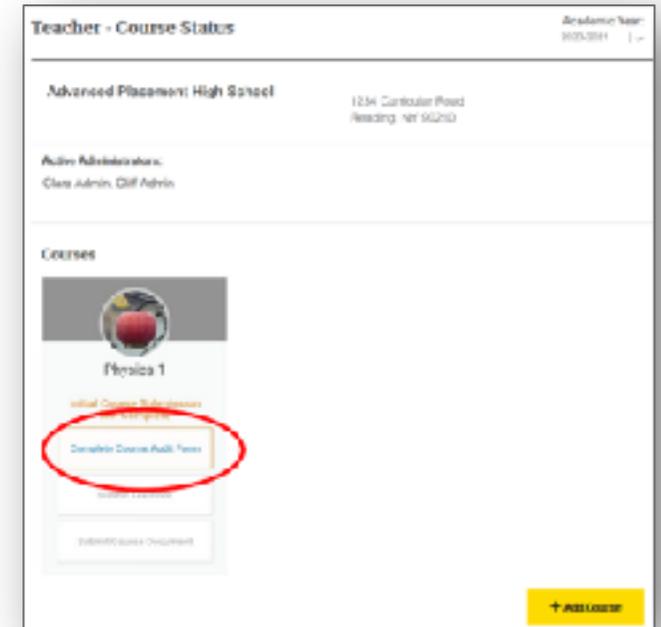
Note: An original course document does <u>not</u> have to be what is used in the classroom. The document submitted needs only address the curricular requirements as described in the required evidence statements outlined in the **AP Course Audit Syllabus Development Guide**.

2025-26 AP Course Audit Process: AP Physics

Submission Options

https://apcentral.collegeboard.org/media/pdf/ap-course-audit-user-guide.pdf

AP Teacher Access to AP Classroom
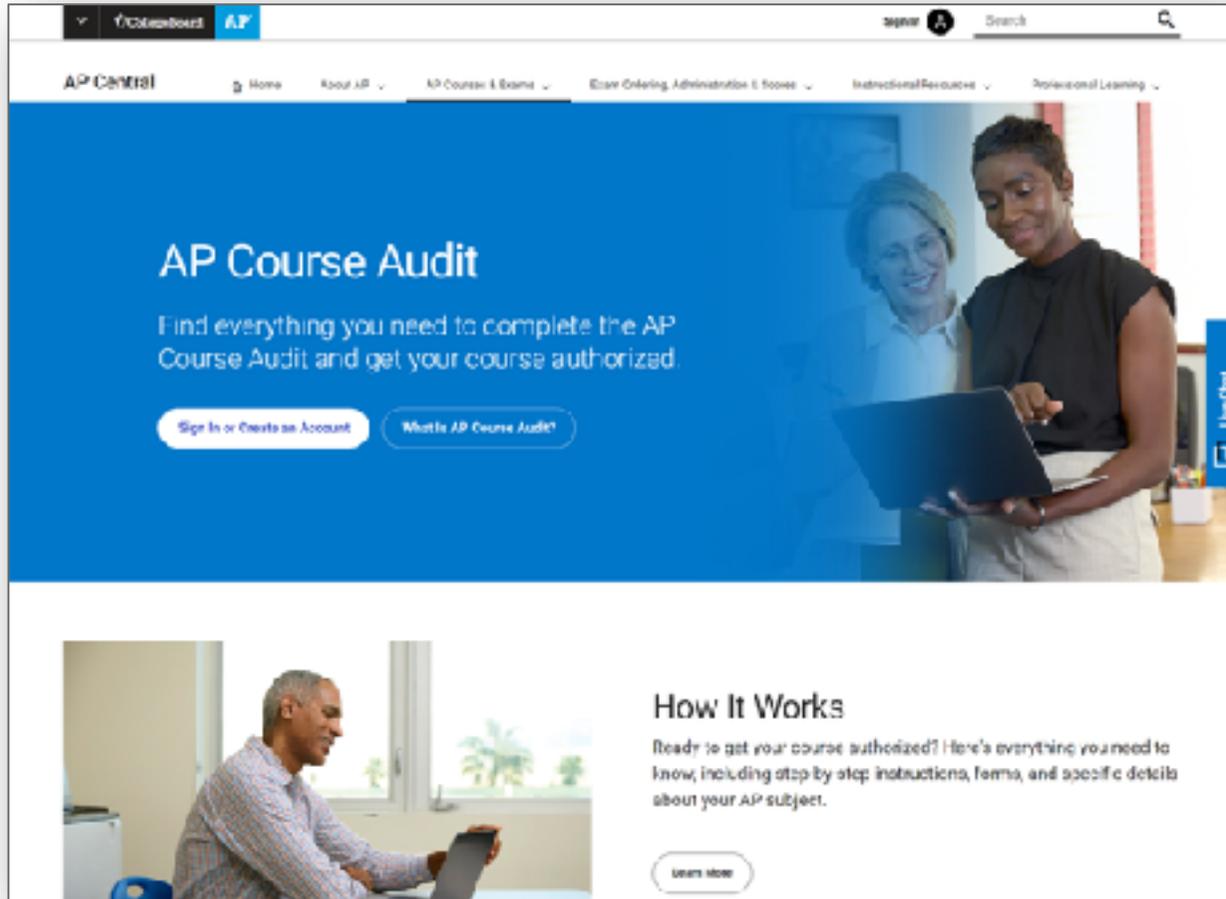
- For AP Physics teachers to be able to access AP Classroom AND to be able to create class sections for the 2025-26 school year, **only two actions are necessary.**

    - The AP teacher must complete and submit the AP Course Audit form.

    - The AP Course Audit Administrator must approve the form.

- **Important:** Selecting and completing one of the syllabus submission options is **not** required for access to AP Classroom or to create class sections.

- Teachers can access AP Classroom at **https://myap.collegeboard.org**. Bookmark this website!!!

Example AP Physics 1 Textbook List

- Cutnell, John D., Kenneth W. Johnson, David Young, Shane Stadler. Physics (Physics 1). 10th edition. Wiley.
- Etkina, Eugenia, Michael Gentile, and Alan Van Heuvelen. College Physics. 2nd edition. National Geographic Learning/Pearson.
- Etkina, Eugenia, Michael Gentile, and Alan Van Heuvelen. College Physics: Explore and Apply, AP Edition. Pearson.
- Ingram, Douglas and David Anderson. OpenStax College Physics for AP® Course 1. 1st edition. OpenStax.
- Knight, Randall J., Brian Jones, and Stuart Field. College Physics: A Strategic Approach. 4th Edition. Pearson.
- Knight, Randall J., Brian Jones, and Stuart Field. College Physics: A Strategic Approach, AP Edition. Pearson.
- Serway, Raymond A. AP Edition, AP Physics 1. 1st edition. National Geographic.
- Serway, Raymond A. and Chris Vuille. College Physics (AP Edition) 11th edition. National Geographic Learning/Cengage Learning.
- Stewart, Gay, Roger A. Freedman, Todd Ruskell, and Philip R. Kesten. College Physics for the AP Physics 1 Course. 1st Edition. Bedford, Freeman, and Worth.
- Stewart, Gay, Roger A. Freedman, Todd Ruskell, and Philip R. Kesten. College Physics for the AP Physics 1 & 2 Courses. 3rd edition. Bedford, Freeman, and Worth.

Example AP Physics 2 Textbook List

- Cutnell, John D., Kenneth W. Johnson, David Young, Shane Stadler. *Physics (Physics 2).* 10th edition. Wiley.
- Etkina, Eugenia, Michael Gentile, and Alan Van Heuvelen. *College Physics.* 2nd edition. National Geographic Learning/Pearson.
- Etkina, Eugenia, Michael Gentile, and Alan Van Heuvelen. *College Physics: Explore and Apply, AP Edition.* Pearson.
- Ingram, Douglas and David Anderson. *OpenStax College Physics for AP® Course 2.* 1st edition. OpenStax.
- Knight, Randall J., Brian Jones, and Stuart Field. *College Physics: A Strategic Approach.* 4th edition. Pearson.
- Knight, Randall J., Brian Jones, and Stuart Field. *College Physics: A Strategic Approach, AP Edition.* Pearson.
- Serway, Raymond A. and Chris Vuille. *College Physics (AP Edition), AP Physics 2.* 11th edition. National Geographic Learning/Cengage Learning.
- Stewart, Gay, Roger A. Freedman, Todd Ruskell, and Philip R. Kesten. *College Physics for the AP Physics 1 & 2 Courses.* 3rd edition. Bedford, Freeman & Worth.

AP Physics Online Textbook

Openstax.org

Curricular Requirements: Syllabus Development Guide P1

SYLLABUS DEVELOPMENT GUIDE

AP Physics 1

The guide contains the following information:

Curricular Requirements

The curricular requirements are the core elements of the course. A syllabus must provide explicit evidence of each requirement based on the required evidence statement(s). The Unit Guides and the "Instructional Approaches" section of the *AP® Physics 1: Algebra Based Course and Exam Description* (CED) may be useful in providing evidence for satisfying these curricular requirements.

Required Evidence

These statements describe the type of evidence and level of detail required in the syllabus to demonstrate how the curricular requirement is met in the course.

Note: Curricular requirements may have more than one required evidence statement. Each statement must be addressed to fulfill the requirement.

Samples of Evidence

For each curricular requirement, two to three separate samples of evidence are provided. These samples provide either verbatim evidence or clear descriptions of what acceptable evidence could look like in a syllabus. In some samples, the specific language that addresses the required evidence is highlighted in bold text.

Curricular Requirements

CR1 Students and teachers have access to college-level resources, including a college-level textbook and reference materials in print or electronic format.

CR2 The course provides opportunities to develop student understanding of the required content outlined in each of the units described in the AP Physics 1 Course and Exam Description.

CR3 The course provides opportunities for students to develop the skills related to Science Practice 1: Creating Representations.

CR4 The course provides opportunities for students to develop the skills related to Science Practice 2: Mathematical Routines.

CR5 The course provides opportunities for students to develop the skills related to Science Practice 3: Scientific Questioning & Argumentation.

CR6 Students spend a minimum of 25% of instructional time engaged in hands-on laboratory investigations.

CR7 Students engage in hands-on laboratory investigations representative of the topics outlined in the AP Physics 1 Course and Exam Description.

CR8 The course provides opportunities for students to record evidence of their scientific investigations in a portfolio of lab reports or a lab notebook (print or digital format).

Curricular Requirements: Syllabus Development Guide P2

AP

SYLLABUS DEVELOPMENT GUIDE

AP Physics 2

The guide contains the following information:

Curricular Requirements

The curricular requirements are the core elements of the course. A syllabus must provide explicit evidence of each requirement based on the required evidence statement(s). The Unit Guides and the "Instructional Approaches" section of the AP® Physics 2: Algebra-Based Course and Exam Description (CED) may be useful in providing evidence for satisfying these curricular requirements.

Required Evidence

These statements describe the type of evidence and level of detail required in the syllabus to demonstrate how the curricular requirement is met in the course.

Note: Curricular requirements may have more than one required evidence statement. Each statement must be addressed to fulfill the requirement.

Samples of Evidence

For each curricular requirement, two to three separate samples of evidence are provided. These samples provide either verbatim evidence or clear descriptions of what acceptable evidence could look like in a syllabus. In some samples, the specific language that addresses the required evidence is highlighted in **bold** text.

Curricular Requirements

CR1 Students and teachers have access to college-level resources, including a college-level textbook and reference materials in print or electronic format. — *See page: 3*

CR2 The course provides opportunities to develop student understanding of the required content outlined in each of the units described in the AP Physics 2 Course and Exam Description. — *See page: 4*

CR3 The course provides opportunities for students to develop the skills related to Science Practice 1: Creating Representations. — *See page: 6*

CR4 The course provides opportunities for students to develop the skills related to Science Practice 2: Mathematical Routines. — *See page: 7*

CR5 The course provides opportunities for students to develop the skills related to Science Practice 3: Scientific Questioning & Argumentation. — *See page: 8*

CR6 Students spend a minimum of 25% of instructional time engaged in hands-on laboratory investigations. — *See page: 9*

CR7 Students engage in hands-on laboratory investigations representative of the topics outlined in the AP Physics 2 Course and Exam Description. — *See page: 10*

CR8 The course provides opportunities for students to record evidence of their scientific investigations in a portfolio of lab reports or a lab notebook (print or digital format). — *See page: 13*

CollegeBoard

89

Year Long Pacing Activity P1 & P2

- In your group, break up the content into a year long list of units, that doesn't have to match the Course and Exam Description.
- Assign numbers of days/weeks to each unit, include location of breaks.
- Include time for review (hopefully!!).
- List the major content covered in each unit.
- **For each unit list one lab/activity you do during the unit.**

- Exam Dates 2026
  - AP Physics 1: Wednesday May 6 - 12:00pm
  - AP Physics 2: Thursday May 7 - 8:00am

CollegeBoard

Mathematical Routines

FRQ #1 - 10 points

Mathematical Routines FRQ

- Find Question #1 the MR FRQ

- P1 page 193

- P2 page 203

- Read through the CED MR FRQ and the Practice Exam MR FRQ linked in the agenda and identify what tasks they ask students to do

- Recored how many points per part

Mathematical Routines FRQ P1 & P2

The Mathematical Routines question assesses students' ability to use mathematics to analyze a scenario and make predictions about that scenario.

(a) Students will be expected to **symbolically derive relationships between variables, as well as calculate numerical values**. (5pts)

(a) Students will be expected to **create and use representations that describe the scenario**, either to help guide the mathematical analysis (such as drawing a free-body diagram) or that are applicable to the scenario (such as sketching velocity as a function of time). (2pts)

(b) For AP Physics 1 and AP Physics 2, the Mathematical Routines question will ask students to ***make a claim or prediction about the scenario and use appropriate physics concepts and principles to support and justify that claim***. The justification is expected to be a logical and sequential application of physics concepts that demonstrates a student's ability to connect multiple concepts to each other. (3pts)

95

Mathematical Routines FRQ Mech and E&M

The Mathematical Routines question assesses students' ability to use mathematics to analyze a scenario and make predictions about that scenario.

(a) Students will be expected to **symbolically derive relationships between variables, as well as calculate numerical values**. (5pts)

(a) Students will be expected to **create and use representations that describe the scenario**, either to help guide the mathematical analysis (such as drawing a free-body diagram) or that are applicable to the scenario (such as sketching velocity as a function of time). (2pts)

(b) Students will be expected to **symbolically derive relationships between variables, as well as calculate numerical values**. (3pts)

Tips for Derivations and Calculations

- Start with a fundamental Physics Law or Principle

- Show all your Physics work, it is OK to not show every Algebra step

- Try to be as organized as possible and follow a clear path

- For <u>answers</u> to derivations, only use the given variables using the same letters/symbols and physical constants as appropriate

- For calculations do not put the numbers in until you have derived the full equation

- Make sure to include units in any numerical answer, you do not need to include units during your derivation

- Circle or box your answer so it is clear to the Reader

FRQ Booklet: Which Version?

Question 1

There are four versions of Question 1; you will only be answering one version.

Bluebook will indicate which version to answer (J, K, L, or M) and the page number in the booklet.

Make sure you respond in the correct space in the booklet.

Question #1: Mathematical Routines-P1&2

THIS IS A TEST PREVIEW

On exam day, you'll write your answer in the free-response booklet.

In Experiment 1, students release a disk of mass M and radius R from rest at the top of a ramp that makes an angle θ with the horizontal. The disk rolls without slipping, as shown in Figure 1. The rotational inertia of the disk is $I_{disk} = \frac{1}{2}MR^2$. The frictional force exerted on the disk is F_f.
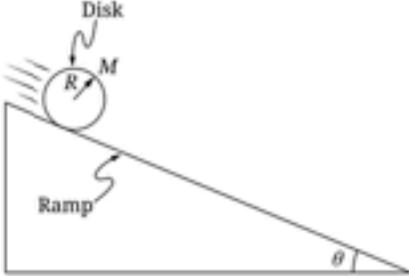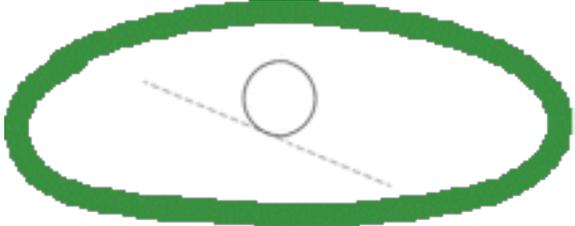
Figure 1

Disk

M

R

Ramp

θ

A.

i. On the diagram in Figure 2, **draw** and **label** arrows that represent the forces (not components) that are exerted on the disk as it rolls down the ramp, which is indicated by the dashed arrow. Each force in your diagram must be represented by a distinct arrow starting on, and pointing away from, the point at which the force is exerted on the disk.

Figure 2

ii. **Determine** an expression for the net torque exerted on the disk around the center in terms of θ, F_f, M, R and physical constants as appropriate.

iii. **Determine** an expression for the net force exerted on the disk in terms of θ, F_f, M, R and physical constants as appropriate.

iv. **Derive** an expression for the translational acceleration of the center of mass of the disk. Express your answer in terms of θ, M, R and physical constants as appropriate. Begin your derivation by writing a fundamental physics principle or an equation from the reference information.

FRQ Booklet Structure

FRQ Booklet Structure: Label Sub-parts

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 1: Version J

PART A

An image will appear here for students to write on.

SAMPLE

PART B

Go to Question 2 in Bluebook when you're done with this question.

Page 3

Go to Question 2 in Bluebook when you're done with this question.

Switching Modes in Desmos AGAIN!!

Mathematical Routines Skills: 1.A 1.C 2.A 2.B 3.B 3.C

Practice 1

Creating Representations 1
Create representations that depict physical phenomena.

Practice 2

Mathematical Routines 2
Conduct analyses to derive, calculate, estimate, or predict.

Practice 3

Scientific Questioning and Argumentation 3
Describe experimental procedures, analyze data, and support claims.

SKILLS

1.A Create diagrams, tables, charts, or schematics to represent physical situations.

1.B Create quantitative graphs with appropriate scales and units, including plotting data.

1.C Create qualitative sketches of graphs that represent features of a model or the behavior of a physical system.

2.A Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway.

2.B Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway.

2.C Compare physical quantities between two or more scenarios or at different times and locations in a single scenario.

2.D Predict new values or factors of change of physical quantities using functional dependence between variables.

3.A Create experimental procedures that are appropriate for a given scientific question.

3.B Apply an appropriate law, definition, theoretical relationship, or model to make a claim.

3.C Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.

103

Mathematical Routines

FRQ #1 - 10 points

P1 2025

⊖ QUESTION 1 MATHEMATICAL ROUTINES (MR)	**10**	4.7
MR PART A POINT 1	1	0.8
MR PART A POINT 2	1	0.4
MR PART A POINT 3	1	0.6
MR PART A POINT 4	1	0.5
MR PART A POINT 5	1	0.7
MR PART A POINT 6	1	0.6
MR PART A POINT 7	1	0.4
MR PART B POINT 1	1	0.4
MR PART B POINT 2	1	0.1
MR PART B POINT 3	1	0.2

CollegeBoard

P2 2025

Question	Max Score	Mean	
			Global
⊖ QUESTION 1 MATHEMATICAL ROUTINES (MR)	10		5.3
MR PART A POINT 1	1		0.8
MR PART A POINT 2	1		0.5
MR PART A POINT 3	1		0.8
MR PART A POINT 4	1		0.6
MR PART A POINT 5	1		0.6
MR PART A POINT 6	1		0.6
MR PART A POINT 7	1		0.3
MR PART B POINT 1	1		0.6
MR PART B POINT 2	1		0.4
MR PART B POINT 3	1		0.2

Derive an equation for μ_K between the block and table in terms of the given variables and fundamental constants.
Note: Massless/Frictionless Pulley & d>>h
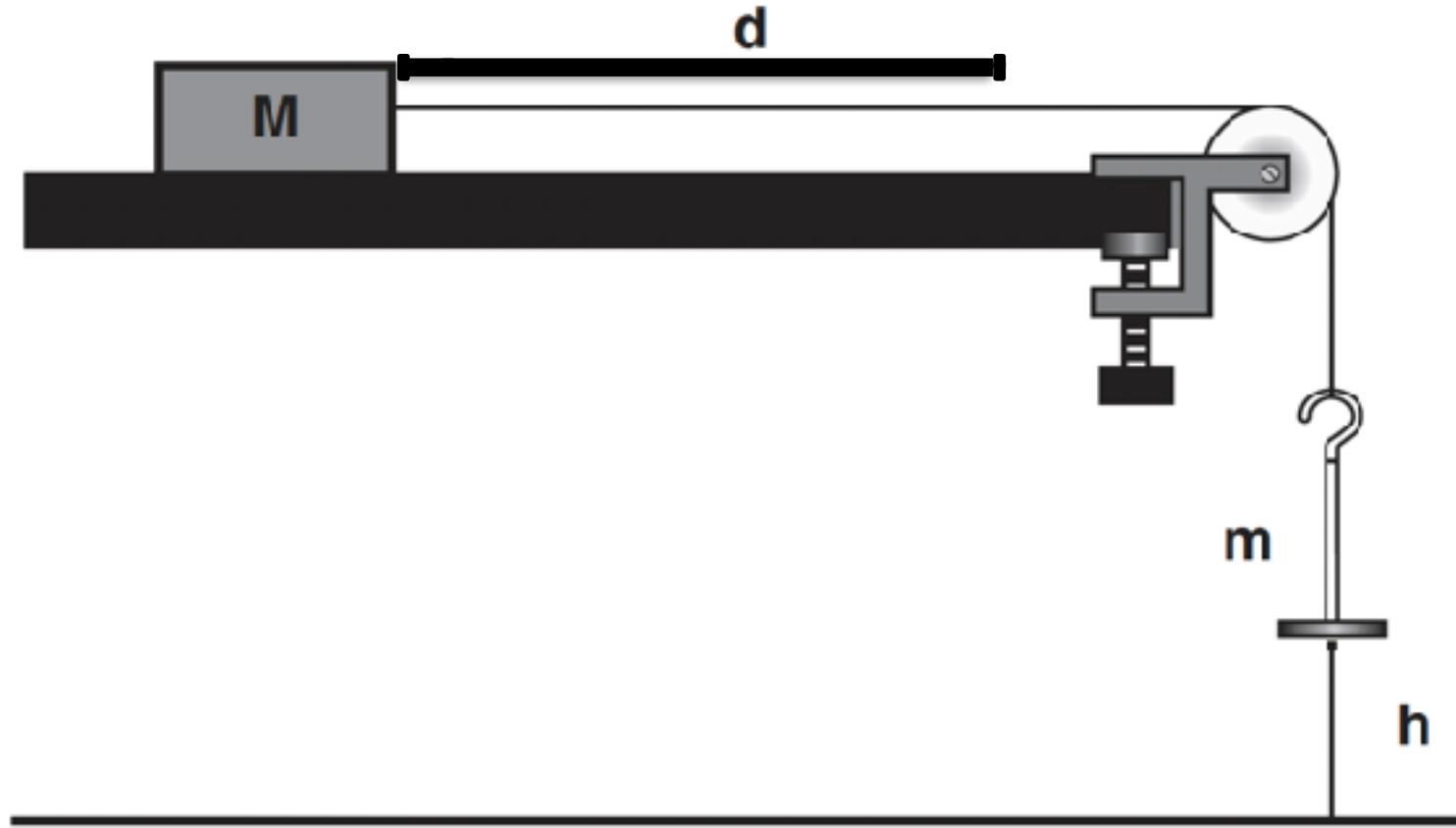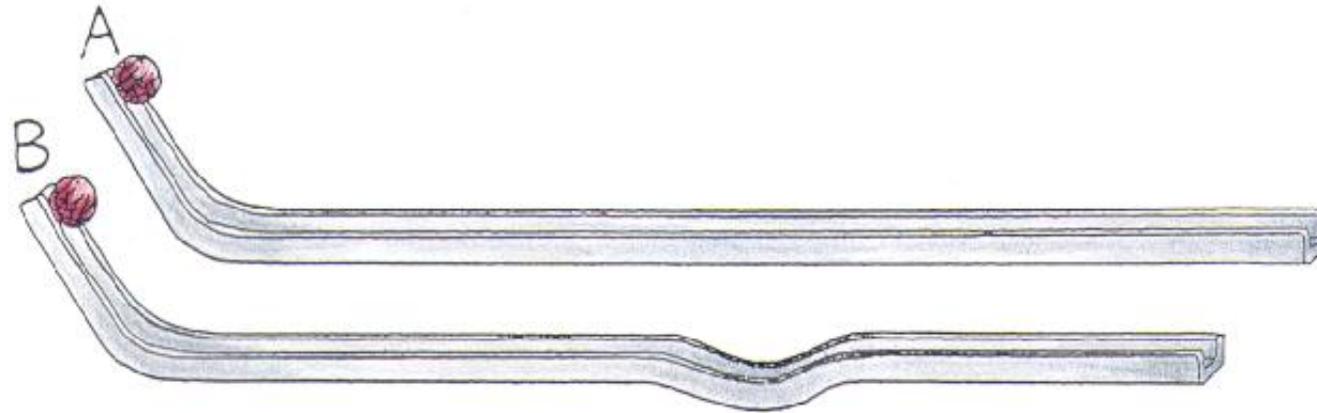
Tracks A and B are made from pieces of channel iron of the same length. They are bent identically except for the same dip in Track B as shown.
When the balls are simultaneously released on both tracks as indicated, the ball that races to the end of the track first is on
a) Track A.
b) Track B.
c)...Both reach the end at the same time.

Instructional Strategies for Effective Writing in AP Physics

Oather Strawderman

International Lead
AP Physics Consultant

Scientific Writing

Strategies and Processes

CER

Claim

Evidence

Reasoning

- Framework for writing scientific arguments
- Tool students can use to answer "Justify your answer" questions
- Students may be familiar with this framework from other classes
- **Claim**: short statement that answers the question
- **Evidence**: information from the question or event description
- **Reasoning**: using Physics principles to synthesize your evidence into your Claim

Switch-it Up

Focus on the order

- CER is a great method, but…..
- Don't start with answering the question!!
- Most of the time when students start with an answer it comes from their gut and not their brain, seen it thousands of times at the Reading
- Start with things they see and then tie them to Physics principles

ERC

Evidence

Reasoning

Claim

- <u>NEW ORDER</u>

- **Evidence**: information from the question or event description

- **Reasoning**: using Physics principles to synthesize your evidence into your Claim

- **Claim**: short statement that answers the question

A

B

Tracks A and B are made from pieces of channel iron of the same length. They are bent identically except for the same dip in Track B as shown. When the balls are simultaneously released on both tracks as indicated, the ball that races to the end of the track first is on

    a) Track A.

    b) Track B.

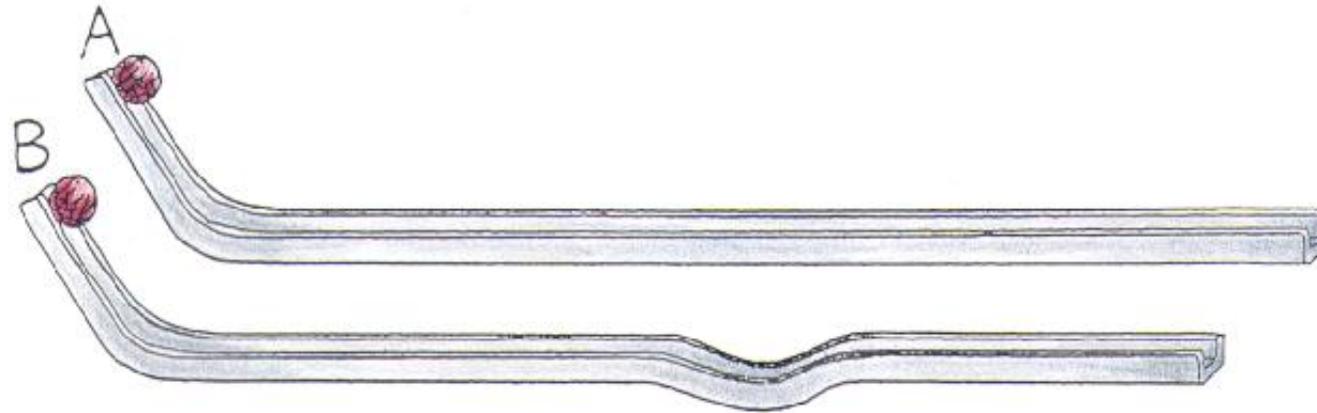   c)...Both reach the end at the same time.

ERC

Evidence

Reasoning

Claim

- <u>NEW ORDER</u>

- **Evidence**: information from the question or event description

- **Reasoning**: using Physics principles to synthesize your evidence into your Claim

- **Claim**: short statement that answers the question

Block 1

d

Table 1

h

Team 1

Block 2

d

Table 2

h

Team 2
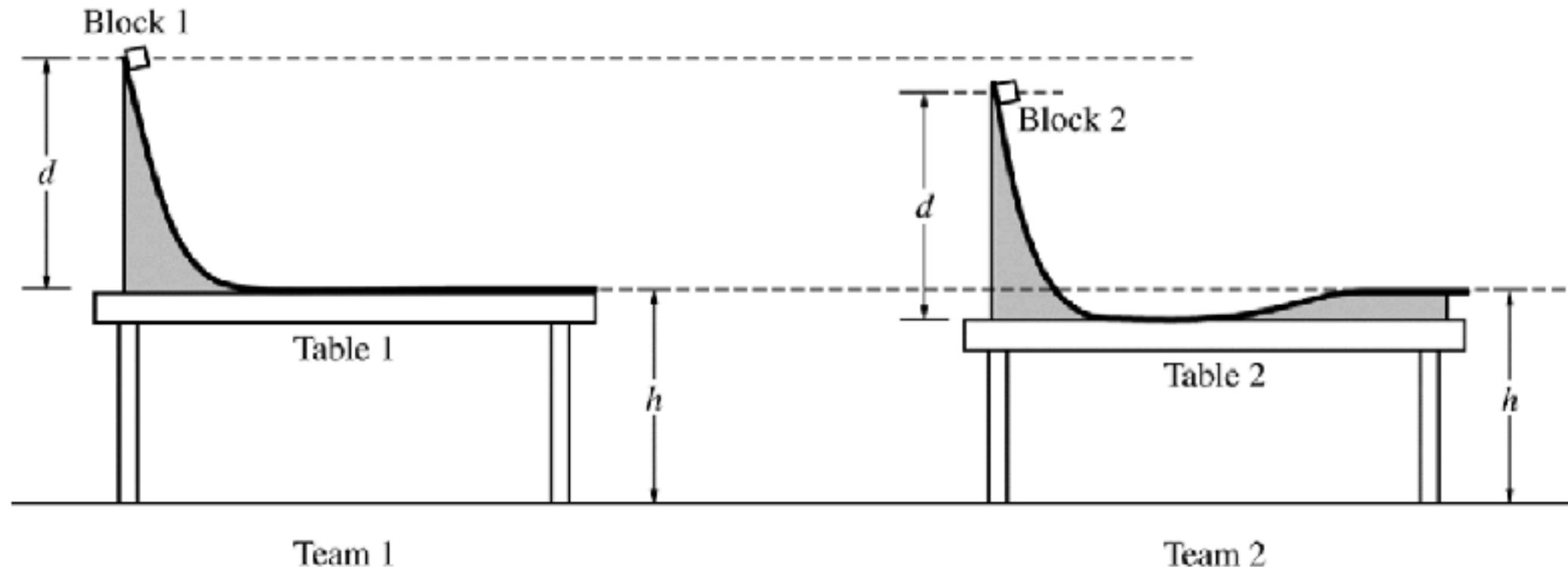
4. (7 points, suggested time 13 minutes)

A physics class is asked to design a low-friction slide that will launch a block horizontally from the top of a lab table. Teams 1 and 2 assemble the slides shown above and use identical blocks 1 and 2, respectively. Both slides start at the same height d above the tabletop. However, team 2's table is lower than team 1's table. To compensate for the lower table, team 2 constructs the right end of the slide to rise above the tabletop so that the block leaves the slide horizontally at the same height h above the floor as does team 1's block (see figure above).

(a) Both blocks are released from rest at the top of their respective slides. Do block 1 and block 2 land the same distance from their respective tables?

_____ Yes   _____ No

Justify your answer.

For attempting to use conservation of energy to compare the two blocks   1 point
For explicitly or implicitly indicating that the launch velocities are different   1 point
For stating or implying that the time to reach the ground is the same for both blocks   1 point

Example: The amount of potential energy converted to kinetic energy is different for the two blocks. The potential energy is proportional to the change in height, which is smaller for block 2. Therefore, at the edge of the table, block 1 will have more kinetic energy than block 2, and hence a larger speed. The launches are both horizontal and from the same height, so the blocks will spend the same amount of time in the air. Because $d = vt$, the distances will be different for the two blocks (as the speeds are different).

Time t_1
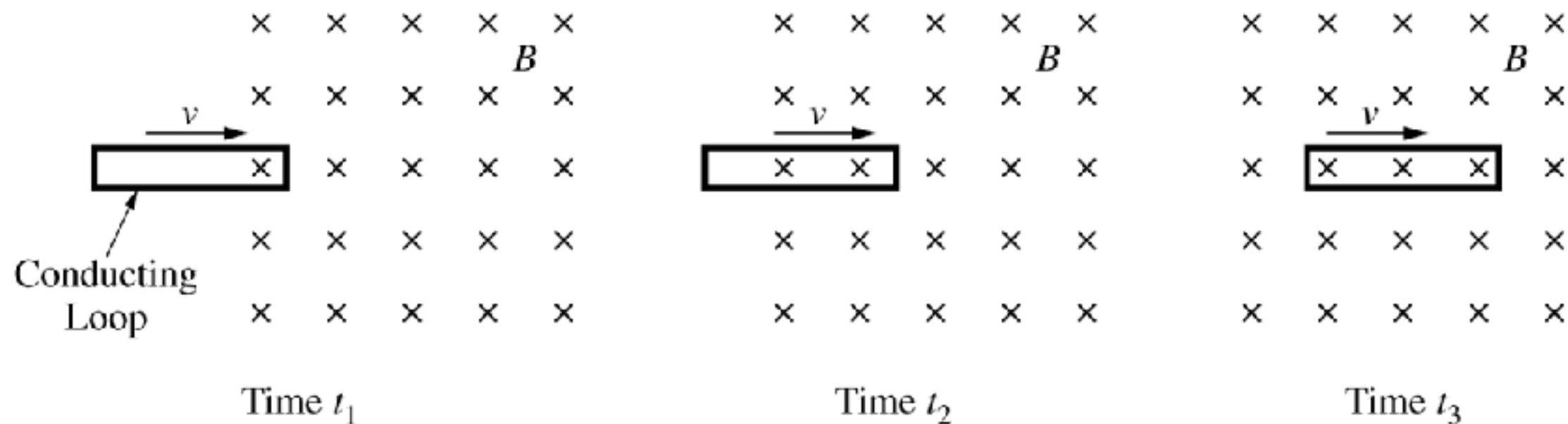
Time t_2

Time t_3

1. (10 points, suggested time 20 minutes)

The figures above show a rectangular conducting loop at three instants in time. The loop moves at a constant speed v into and through a region of constant, uniform magnetic field B directed into the page. The magnetic field is zero outside the region.

(a) In a coherent paragraph-length response, compare the magnitude and direction of the current at times t_1, t_2, and t_3. Include an explanation of why there is or is not a current and the direction of the current if one is present. Use fundamental physics concepts and principles in your explanation.

For indicating that the currents at t_1 and t_2 have equal nonzero magnitudes and are in the same direction		1 point
For indicating that there is no current at t_3		1 point
For correctly indicating that the currents depend on the change in flux through the loop or the forces on the charges moving in the field		1 point
For correctly identifying the direction of the current as counter-clockwise and either explaining that the direction of the current generates a magnetic field that opposes the change in flux <u>or</u> analyzing the force on the charge carriers in each segment of the loop		1 point
For an on-topic response that has sufficient paragraph structure, as described in the published requirements for the paragraph length response		1 point

A new pendulum is made by hanging the same small sphere from a different string with negligible mass. The new string is slightly elastic, and the length of the string may increase or decrease depending on the tension applied to the string. On Earth, when the sphere is again displaced θ from the vertical and released from rest, the new pendulum oscillates with period T_E.

The new pendulum is then taken to a different planet, Planet Y. The radius of Planet Y is the same as the radius of Earth, but the mass of Planet Y is larger than the mass of Earth. On Planet Y, when the sphere is again displaced from the vertical and released from rest, the new pendulum oscillates with period T_Y.

(b) In a clear, coherent paragraph-length response that may also contain drawings, **explain** how T_Y <u>could be larger</u> than T_E but also <u>could be smaller</u> than T_E.
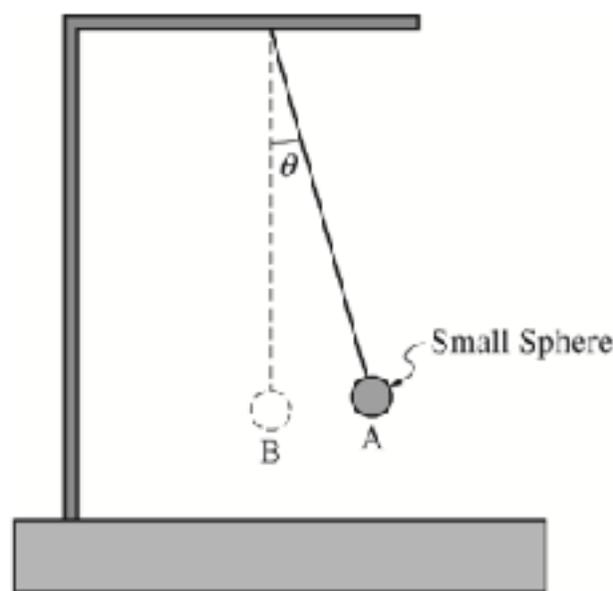
For relating a larger planetary mass to a **one** of the following:	1 point

- A larger weight of the sphere
- A larger acceleration due to gravity g
- A larger gravitational field strength

For indicating that the period is inversely related to **one** of the following:	1 point

- The acceleration due to gravity g
- The gravitational field strength

For indicating that the amount of stretch is dependent on **one** of the following:	1 point

- The weight of the sphere
- The acceleration due to gravity g
- The gravitational field strength

For relating the length of the string to the period of the pendulum	1 point
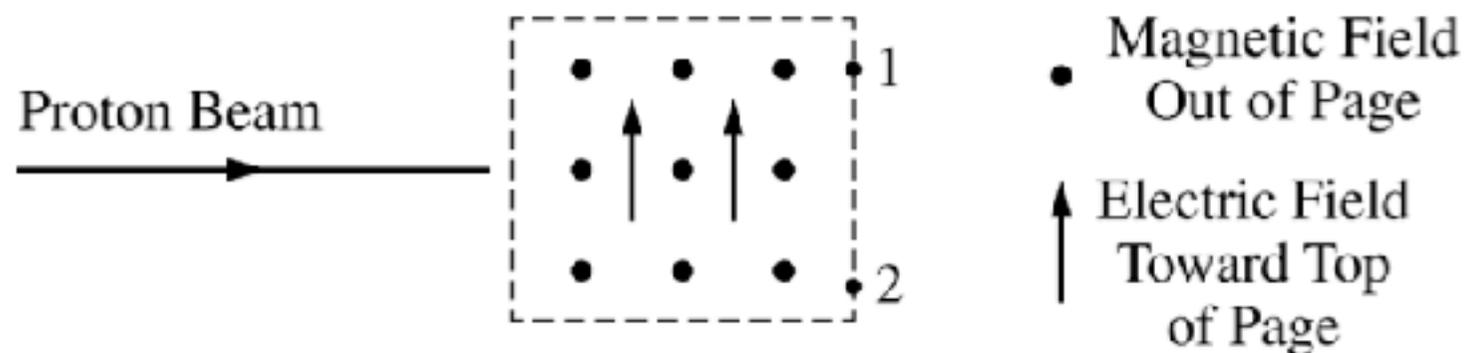
Another region of space contains an electric field directed toward the top of the page and a magnetic field directed out of the page. Both fields are constant and uniform. A horizontal beam of protons with a variety of speeds enters the region, as shown above. Protons exit the region at a variety of locations, including points 1 and 2 shown on the figure. In a coherent, paragraph-length response, explain why some protons exit the region at point 1 and others exit at point 2. Use physics principles to explain your reasoning.

For indicating that initially the electric and magnetic forces act in opposite directions		1 point
For indicating or implying that the magnetic force is affected by speed, but the electric force is not		1 point
For indicating that different paths occur as a result of the addition of forces		1 point
For indicating that slower protons exit higher than faster protons (i.e., slower protons exit at point 1 and faster protons exit at point 2)		1 point
For a logical, relevant, and internally consistent argument that addresses the question asked and follows the guidelines described in the published requirements for the paragraph-length response		1 point
Example: For a charged particle to travel through the region undeflected, the net force on it must be zero. This means that the upward electric force and the downward magnetic force must be equal and opposite to each other. This occurs for a particular speed. The electric force is independent of the particle's velocity, but the magnetic force will be larger for greater velocities and less for smaller velocities. If a particle is moving faster than the particular speed, it will experience a greater magnetic force and be deflected downward. If it is moving more slowly than the particular speed, it will be deflected upward.		

ERC

Q

$2m$

P

m

x_0
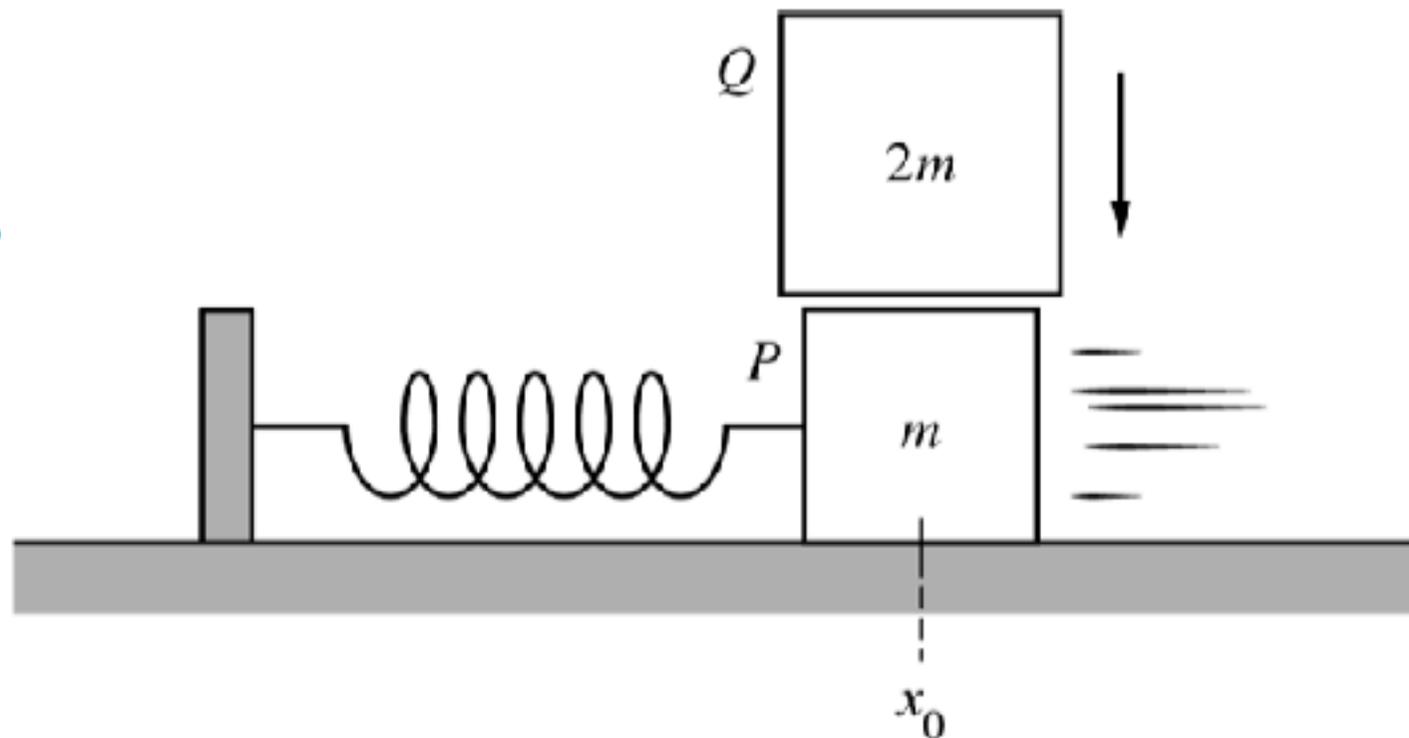
(b) The figure is reproduced above. How does the amplitude of oscillation A_{PQ} of the two-block system compare with the original amplitude A_P of block P alone?

_____ $A_{PQ} < A_P$ _____ $A_{PQ} = A_P$ _____ $A_{PQ} > A_P$

In a clear, coherent paragraph-length response that may also contain diagrams and/or equations, explain your reasoning.

Correct answer: $A_{PQ} < A_P$.	
Note: The response is graded even if an incorrect selection is made.	
For applying conservation of momentum to the collision	1 point
For correctly finding that the post-collision speed has decreased (or, for determining that $v_f = \frac{1}{3}v_i$)	1 point
Note: The first 2 points can be earned for stating that the collision is inelastic	
For stating or implying that the system's kinetic energy has decreased (or, for calculating a lower final kinetic energy)	1 point
For stating or implying kinetic energy of blocks right after collision equals maximum potential energy of spring OR For stating or implying that the maximum potential energy equals the total mechanical energy just after the collision (Simply stating that $E_{tot} = \frac{1}{2}kA^2$ is sufficient.)	1 point
For stating or implying that maximum potential energy is reached when the displacement from equilibrium equals the amplitude of oscillation	1 point
Note: The previous 2 points can be earned in a single sentence in which one or both of the points is implicit.	

Tips

Just write it!

- Write every day!

- Start small, one sentence statements

- Start early!!

- Scaffold what you are asking them to do both Physics wise and writing wise….don't jump into lengthy responses in Unit 1

- Give them a framework to use that you teach and continually use…just like you do with Quantitative problems

- Present material in ways that foster writing vs just computation

- Show students the rubrics

Experimental Design and Analysis FRQ

FRQ #3 - 10 points

Experimental Design and Analysis FRQ Tasks

- Open up your Physics CEDs
- Find Question #3 the LAB FRQ
- P1 page 196
- P2 page 205

- Read through the CED LAB FRQ and the Practice Exam LAB FRQ linked in the agenda and identify what tasks they ask students to do
- Recored how many points per part

Experimental Design and Analysis (LAB)

Skills: `1.B` `2.B` `2.D` `3.A` `3.B` `3.C`

10 points; suggested time: 25-30 minutes

The Experimental Design and Analysis (LAB) question assesses students' ability to create scientific procedures that can be used with appropriate data analysis techniques to determine the answer to given questions. The LAB question can roughly be divided into two sections: Design and Analysis. In the Design portion of the LAB question, students will be asked to develop a method by which a question about a given physical scenario could be answered. The experimental procedure is expected to be scientifically sound: vary a single parameter, and measure how that change affects a single characteristic. Methods must be able to be performed in a typical high school laboratory. Measurements must be made with realistically obtainable equipment or sensors. Students will be expected to describe a method by which the collected data could be analyzed in order to answer the posed question, by either graphical or comparative analyses.

Students will then be given experimental data collected in order to answer a similar, but not identical, question to what was asked in the Design portion of the question. Students will be asked to use the data provided to create and plot a graph that can be analyzed to determine the answer to the given question. For instance, the slope or intercepts of the line may be used to determine a physical quantity or perhaps the nature of the slope would answer the posed question.

Experimental Design & Analysis FRQ

Tasks

Experiment 1

- **Describe** an experimental procedure including multiple Independent Variable values (Part A-2pts)

- **Describe** how the data can be graphed and analyzed (Part B-2pts)

Experiment 2

- **Indicate** which measured or calculated quantity could be plotted to yield a linear graph (Ci-1pt)

- **Scale** & **Label** all axes and **Plot** the quantities (Cii-2pts)

- **Draw** a best fit line (Ciii-1pt)

- **Calculate** an experimental value using an equation and the graph's slope (D-2pts)

LAB Skills: 1.B 2.B 2.D 3.A

Practice 1	**Practice 2**	**Practice 3**
Creating Representations [1]	*Mathematical Routines* [2]	*Scientific Questioning and Argumentation* [3]
Create representations that depict physical phenomena.	Conduct analyses to derive, calculate, estimate, or predict.	Describe experimental procedures, analyze data, and support claims.

SKILLS

1.A Create diagrams, tables, charts, or schematics to represent physical situations.	**2.A** Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway.	**3.A** Create experimental procedures that are appropriate for a given scientific question.
1.B Create quantitative graphs with appropriate scales and units, including plotting data.	**2.B** Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway.	**3.B** Apply an appropriate law, definition, theoretical relationship, or model to make a claim.
1.C Create qualitative sketches of graphs that represent features of a model or the behavior of a physical system.	**2.C** Compare physical quantities between two or more scenarios or at different times and locations in a single scenario.	**3.C** Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.
	2.D Predict new values or factors of change of physical quantities using functional dependence between variables.	

133

Question #3: Experimental *Design* and Analysis

A group of students are given a cylindrical container half filled with a liquid of unknown density ρ as shown in Figure 1. The students have access to an additional container with more of the same liquid, meter sticks, and a pressure sensor. They do not have access to a scale.

Figure 1

Container —
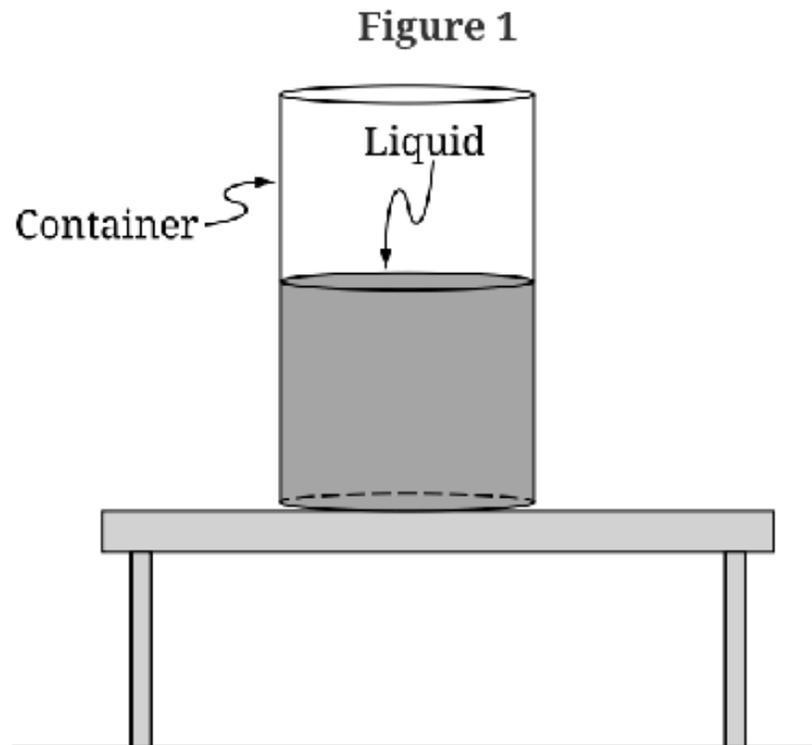
Liquid

A. i. **Indicate** quantities that could be measured by the students that would allow them to determine the density of the liquid using a linear graph.

    ii. Briefly **describe** a method to reduce experimental uncertainty for the measured quantities.

B. i. **Indicate** what quantities students could graph on the horizontal and vertical axes to create a linear graph that can be used to determine the density of the liquid.

    ii. Briefly **describe** the relationship between the density of the liquid and a feature of the graph from Part B (i). Your answer may include an equation that relates the density of the liquid and the chosen feature of the graph.

Question #3: Experimental Design and _Analysis_: P1
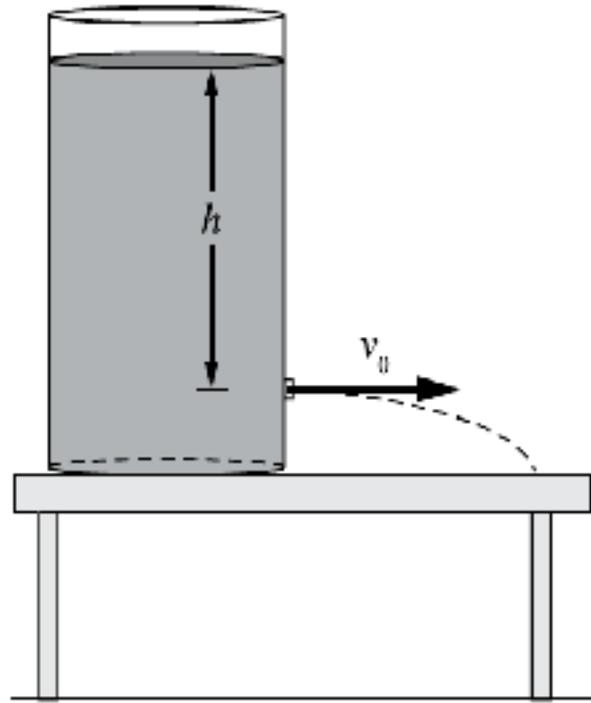
Figure 2

The students perform another experiment with another cylindrical container which is filled with water, as shown in Figure 2. The students make a small hole in the side of the cylinder and measure the speed v at which water exits the hole. The students plug the first hole, make another one at a different height, and repeat this procedure. Table 1 shows the height h of each hole relative to the top of the water, and the corresponding water speed v.

Question #3: Experimental Design and *Analysis*: P1

Table 1

Height h (m)	Speed v (m/s)
0.25	2.2
0.20	2.0
0.15	1.8
0.10	1.4
0.05	1.1

C. The students correctly determine that the relationship between h and v is given by

$$v = \sqrt{2gh}$$

The students want to determine an experimental value for the acceleration due to gravity. The students create a graph with v^2 plotted on the vertical axis.

i. **Label** the horizontal axis of Figure 3 with a measured or calculated quantity. Include units, as appropriate. The graphed quantities should yield a linear graph that can be used to determine the acceleration due to gravity.

ii. On the grid provided in Figure 3, create a graph of the quantities indicated in part C (i).

- Clearly **label** the horizontal axis with a numerical scale.
- **Plot** the corresponding data points on the grid.
- Table 2 is provided in your booklet for scratch work and will not be scored.

iii. **Draw** a best fit line for the data graphed in part C (ii).

D. **Calculate** an experimental value for the acceleration due to gravity using the best-fit line that you drew in part C (iii).

Figure 3

v^2 (m^2/s^2)
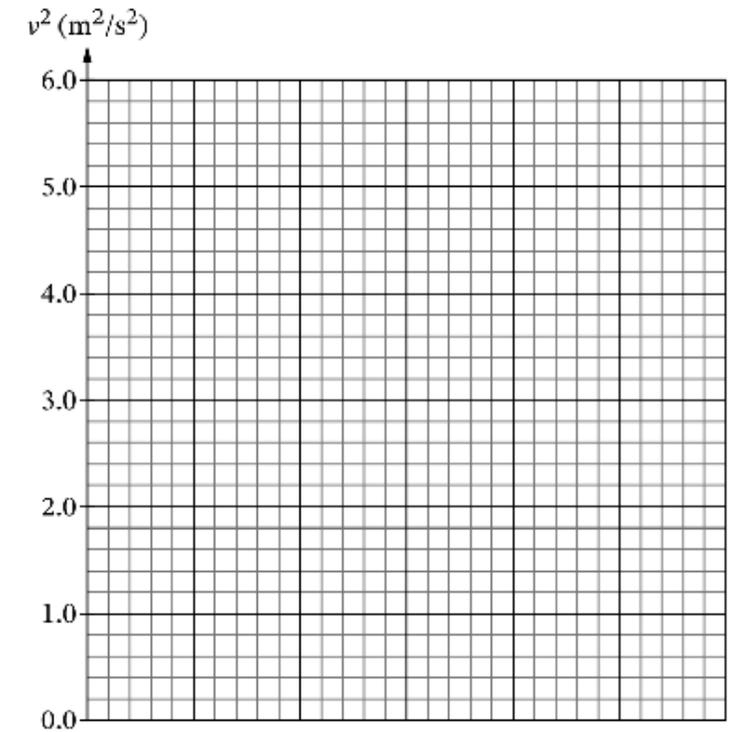
Quantity	Units (if appropriate)
_____	_____

Question #3: Experimental Design and *Analysis*: P2&Cs
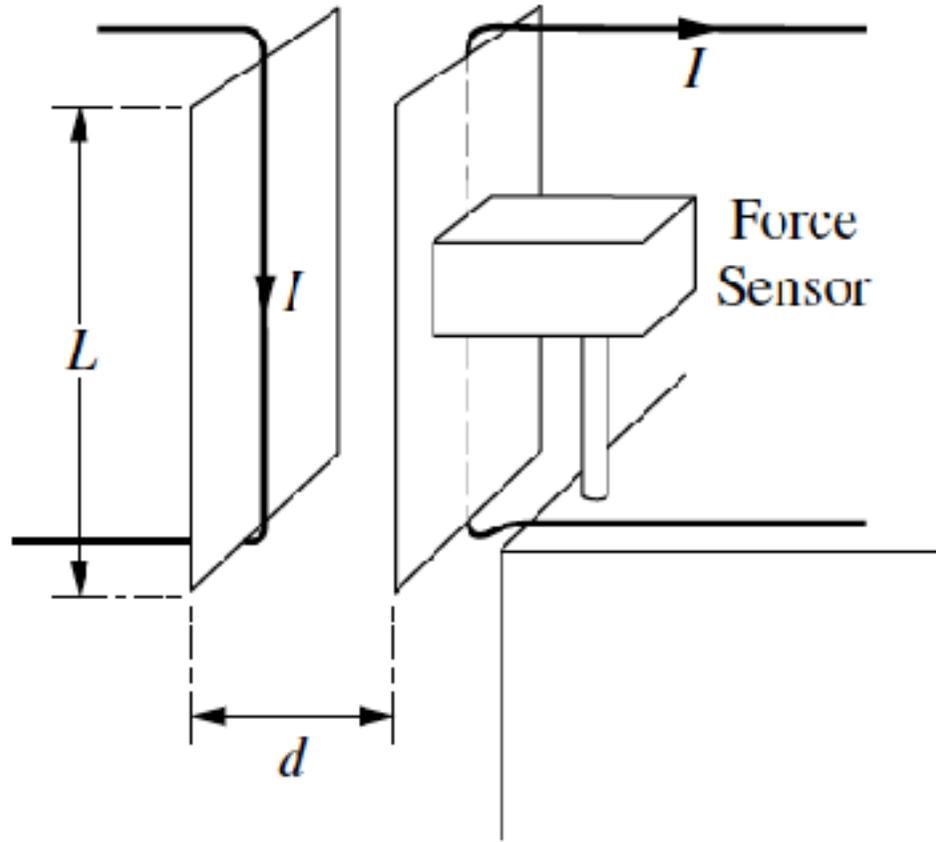
The students want to determine an experimental value for the magnetic permeability of free space, μ_0. The same experimental setup is used and the current I is the same for both wires, as shown in Figure 2. The length L of the wire segments fixed to the boards is measured. In this experiment the distance d between the wires is held fixed and the force is measured while the current I is then varied. Using measured values of $L=1.4$ m and $d=0.005$ m, the students collect the data shown in Table 1.

Table 1

I (A)	F (mN)
2.8	0.35
3.2	0.60
3.6	0.65
4.0	1.00
4.4	1.10

(c) i. **Label** the axes of the grid provided with measured or calculated quantities. Include units, as appropriate. The graphed quantities should yield a linear graph that can be used to determine μ_0.

ii. On the grid provided, create a graph of the quantities indicated in part (c)i.

- Clearly **label** the axes with a numerical scale.

- **Plot** the corresponding data points on the grid.

- Table 2 is provided in your booklet for scratch work and will not be scored.

iii. **Draw** a best-fit line for the data plotted in part (c)(ii).

(d) Using the line drawn in part (c)(iii) and the measured values $L=1.4$ m and $d=0.005$ m as needed, **calculate** the magnetic permeability of free space, μ_0.

Quantity   (Units, if appropriate)
_____   _____
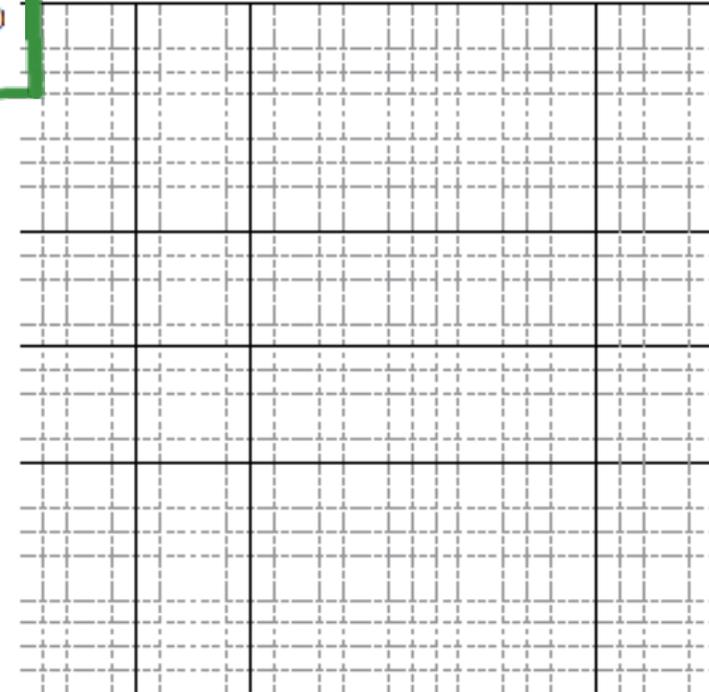
Quantity   Units (if appropriate)
_____   _____

Experimental Design and Analysis (LAB)

Skills: `1.B` `2.B` `2.D` `3.A` `3.B` `3.C`

10 points; suggested time: 25-30 minutes

The Experimental Design and Analysis (LAB) question assesses students' ability to create scientific procedures that can be used with appropriate data analysis techniques to determine the answer to given questions. The LAB question can roughly be divided into two sections: Design and Analysis. In the Design portion of the LAB question, students will be asked to develop a method by which a question about a given physical scenario could be answered. The experimental procedure is expected to be scientifically sound: vary a single parameter, and measure how that change affects a single characteristic. Methods must be able to be performed in a typical high school laboratory. Measurements must be made with realistically obtainable equipment or sensors. Students will be expected to describe a method by which the collected data could be analyzed in order to answer the posed question, by either graphical or comparative analyses.

Students will then be given experimental data collected in order to answer a similar, but not identical, question to what was asked in the Design portion of the question. Students will be asked to use the data provided to create and plot a graph that can be analyzed to determine the answer to the given question. For instance, the slope or intercepts of the line may be used to determine a physical quantity or perhaps the nature of the slope would answer the posed question.

LAB: Experimental Design and Analysis

Experiment 1: Design

- Describe an experimental procedure including multiple Independent Variable values
- Describe how the data can be graphed and how the graph can be analyzed to determine the unknown quantity

Experiment 2: Analysis

- Determine which measured or calculated quantities could be plotted to yield a linear graph
- Scale & Label axes and Plot the quantities
- Draw a best fit line
- Calculate an experimental value using an equation and the graph

FRQ Booklet: Which Version? P1

Question 3

There are four versions of Question 3; you will only be answering one version.

Bluebook will indicate which version to answer (J, K, L, or M) and the page number in the booklet.

Make sure you respond in the correct space in the booklet.

Page 17

FRQ Booklet Structure: Question #3 LAB: P1

Question 3

PART A

PART B

Question 3 is continued on the next page.

Question 3

PART C

v^2 (m^2/s^2)

Table 2

Quantity   Units (if appropriate)

PART D

Go to Question 4 in Bluebook when you're done with this question.

FRQ Booklet Structure: Question #3 LAB - P2 & Cs

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 3
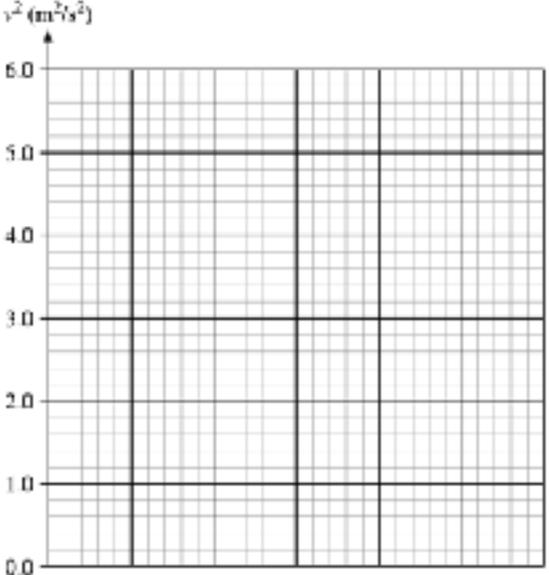
PART A

PART B

Page 16

Question 3 is continued on the next page.

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 3

PART C

Quantity   (Units, if appropriate)

Table 2

Quantity   Units (if appropriate)

PART D

Page 17

Go to Question 4 in Bluebook when you're done with this question.

Experimental Design Part: Tips

- Use the Reference Table equations to guide your thinking to decide what quantity you will vary and what quantity will vary as a result

- Make sure and mention that you will vary the independent variable many times (10 times for example) to reduce experimental uncertainty

- Be very clear which axis which quantity will be graphed on in Part B.

- Show the equation you are using and how the slope of the graph will give you the unknown quantity, write derivation in $y=mx+b$ format

Experimental Analysis Part: Tips

- Use the Reference Table equations to guide your thinking to decide what quantity you will vary and what quantity will vary as a result

- **Tip:** Use the space in Part D to do your derivations to determine what you are going to graph, write derivation in $y=mx+b$ format

- Fill out the data table to help the Reader know what values you are plotting but it will not be scored

Experimental Analysis Part: Tips

- Label both axes with the Quantity and the Units, i.e,. length (m) or time (s) or t^2 (s^2)

- Make sure if a quantity is squared in your equation, you plot that quantity squared

- Label each axis with a linear scale of values

- Use as much of your graph as possible, don't have all the dots in the bottom left-hand corner because it makes it difficult to determine if the data points are correctly plotted

- Good rule of thumb is to have an equal number data points above and below the best fit line

Experimental Analysis Part: Tips

- Make it clear how the graph/equation will be used to determine the unknown quantity

- When calculating the slope of the line show your work and make sure to use points on the line

- **Or explicitly state you used your calculator or Desmos**

- Make sure your answer to Part D includes the correct units

Using Desmos to Determine Slope of a Graph

P1 2025

QUESTION 3 EXPERIMENTAL DESIGN AND ANALYSIS (LAB)	10		4.9
LAB PART A POINT 1	1		0.7
LAB PART A POINT 2	1		0.8
LAB PART B POINT 1	1		0.4
LAB PART B POINT 2	1		0.2
LAB PART C POINT 1	1		0.6
LAB PART C POINT 2	1		0.4
LAB PART C POINT 3	1		0.7
LAB PART C POINT 4	1		0.7
LAB PART D POINT 1	1		0.3
LAB PART D POINT 2	1		0.3

P2 2025

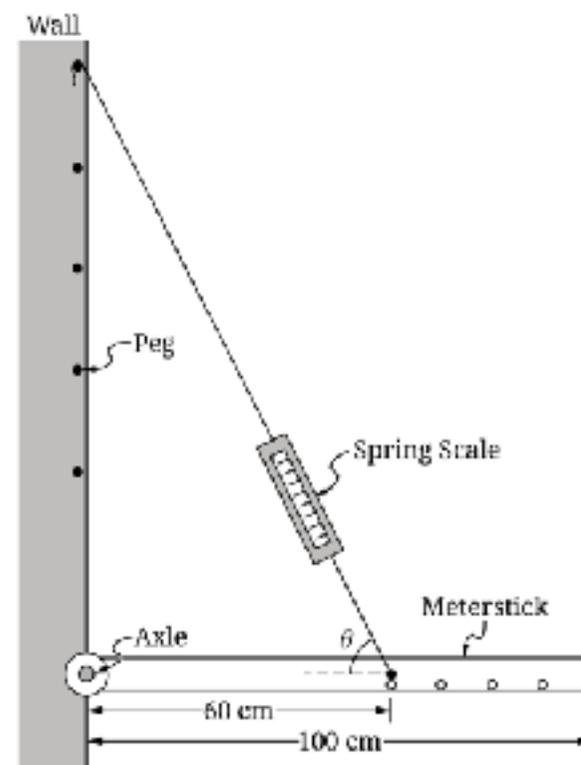| QUESTION 3 EXPERIMENTAL DESIGN AND ANALYSIS (LAB)	10		7.2
LAB PART A POINT 1	1		0.6
LAB PART A POINT 2	1		0.5
LAB PART B POINT 1	1		0.8
LAB PART B POINT 2	1		0.6
LAB PART C POINT 1	1		0.9
LAB PART C POINT 2	1		0.9
LAB PART C POINT 3	1		0.9
LAB PART C POINT 4	1		0.9
LAB PART D POINT 1	1		0.8
LAB PART D POINT 2	1		0.4

3. Students are investigating balancing systems using the following setup. The students have a spring scale of negligible mass that is fixed to one end of a uniform meterstick. The center of the meterstick is attached to a stand on which the meterstick can pivot. There is a hook of negligible mass fixed to the top of a block of mass m_0. The hook can be attached to the meterstick through one of the small holes in the meterstick, as shown in Figure 1. The students do not have a direct way to measure the mass of the block. The block cannot be attached to the spring scale.

Figure 1

Figure 2

The students are asked to take measurements that will allow the students to create a linear graph whose slope could be used to determine the mass m_0 of the block.

A. Describe an experimental procedure to collect data that would allow the students to determine m_0. Include any steps necessary to reduce experimental uncertainty.

B. Describe how the data collected in part A could be graphed and how that graph would be analyzed to determine m_0.

The angle θ that the string makes with the meterstick can be varied by attaching the string to one of the pegs located along the wall. The students use the spring scale to measure the tension F_T required to hold the meterstick horizontal. Table 1 shows the measured values of θ and F_T.

Answer the LAB Question

- With your partner, answer the Torque Lab FRQ #3 P1 2025 linked in Day 1 PM1

- Use Desmos to determine the meterstick mass in Parts C&D

- As you work the FRQ think about how you can help prepare you students for this item type

- How could you adjust how you structure labs to help prepare students?

- How could you adjust what you require in lab reports?

LAB FRQ Practice

- Work through the LAB FRQ for the exam of your choosing

- As you work the FRQ think about how you can help prepare you students for this item type

- How could you adjust how you structure labs?

- How could you adjust what you require in lab reports?

Students are given a small sphere, a stopwatch, and a meterstick and are asked to take measurements to create a graph that could be used to determine the acceleration due to gravity.

(a) **Describe** a procedure for collecting data that can be graphed to determine the acceleration due to gravity. Students have access only to the sphere, stopwatch, and meterstick. Include any steps necessary to reduce experimental uncertainty.

(b) **Describe** how the data collected in part (a) would be graphed, and how that graph would be analyzed to determine the acceleration due to gravity.

Another group of students is given a cart on an inclined track. At the end of the track is a motion sensor which records the velocity of the cart as a function of time. The following table shows the data collected by the students.

Velocity (m/s)	Time (s)	
1.0	0.1	
1.7	0.3	
3.0	0.5	
3.7	0.7	
5	0.9	

Figure 1

The students correctly determine that the relationship between velocity and time is given by $v = (g \sin \theta)t$. The students create a graph with t plotted on the horizontal axis.

(c)

i. **Indicate** which measured or calculated quantity could be plotted on the vertical axis to yield a linear graph whose slope can be used to calculate an experimental value for the angle of the track. You may use the remaining columns in the table, as needed, to record any quantities (including units) that are not already in the table.
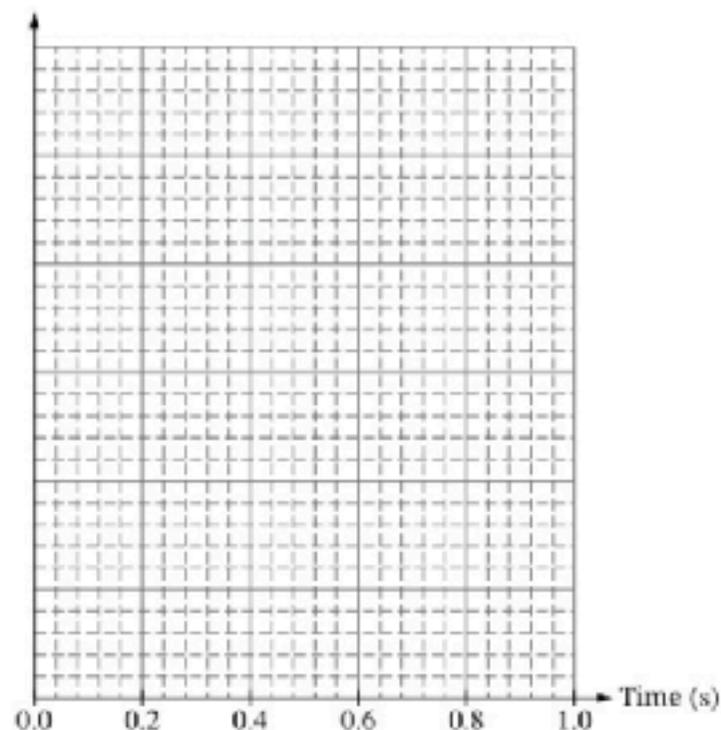
Vertical: _____   Horizontal: _____ t _____

ii. On the grid shown in Figure 1, **plot** the data points for the quantities indicated in part (c)(i) that can be used to determine θ. Scale the graph as appropriate. Clearly **label** the vertical axis, including units.

iii. **Draw** a best–fit line for the data graphed in part (c)(ii).

(d) **Calculate** an experimental value for θ, using the best fit-line you drew in Figure 1 in part (c)(iii).

AP Reading

Scoring the Free Response Questions

AP Reading

- 7 (12) Days long
- Second Week: June 11-17, 2026
- Tampa, Florida
- 2025 (2024 / 2023) Exam Volumes
- **P1 Exams** 174,506 (164,950 / 160,924)
- **P2 Exams** 23,650 (22,831 / 20,597)
- **C:Mech Exams** 66,238 (61,606 / 56,169)
- **C:E&M Exams** 29,946 (28,238 / 24,407)
- 305 Onsite Readers and 329 At-Home Readers
- Mix of HS and college

Scoring Guides

- Rubric points are now uniform across exams.
- Item writers put the Physics into the uniform rubric.
- Test Development Committee has the final say before going to the Reading.
- Leaders 'clarify' the rubric after looking at hundreds of student samples.
- 5 days of Leader meetings
- 7 days of Reading

Reading Positions

- Reader

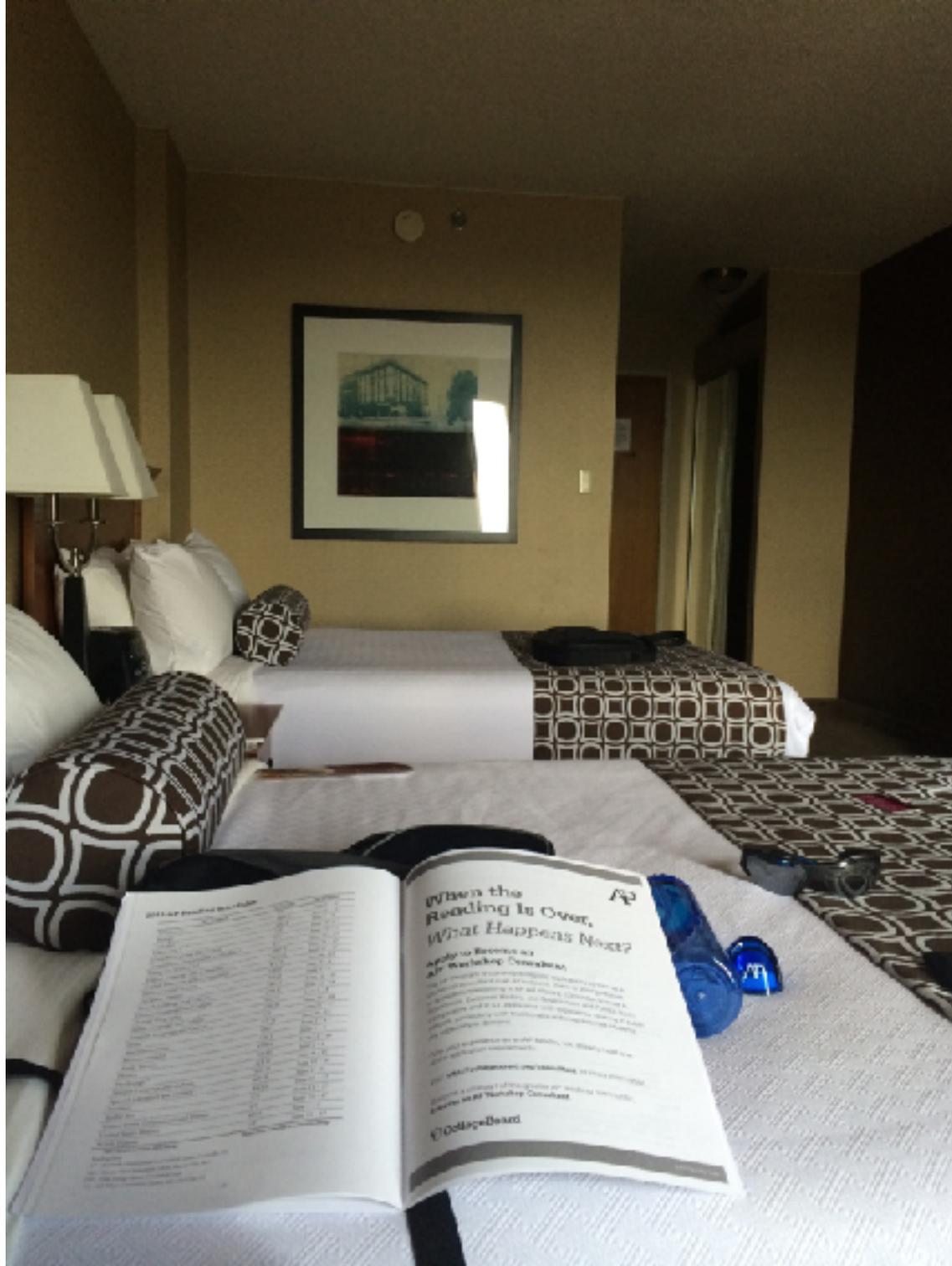- Table Leader

- Question Leader

- Exam Leader

- Chief Reader

Reading Process

- Image projected on a laptop
- Readers grade just one question, not the whole exam.
- Readers decide if a response gets each individual point by clicking a radial button for each rubric point.
- Make sure they use a sharpened pencil or pen
- Focus your students on having good handwriting that is not miniscule.
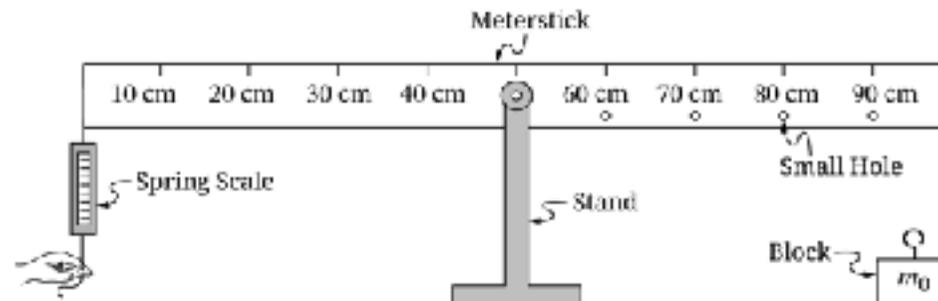
CollegeBoard

When the Reading Is Over, What Happens Next?

Apply to Become an AP® Workshop Consultant

CollegeBoard

Mock Reading Activity

Question 3: Version J

3. Students are investigating balancing systems using the following setup. The students have a spring scale of negligible mass that is fixed to one end of a uniform meterstick. The center of the meterstick is attached to a stand on which the meterstick can pivot. There is a hook of negligible mass fixed to the top of a block of mass m_0. The hook can be attached to the meterstick through one of the small holes in the meterstick, as shown in Figure 1. The students do not have a direct way to measure the mass of the block. The block cannot be attached to the spring scale.

Figure 1

The students are asked to take measurements that will allow the students to create a linear graph whose slope could be used to determine the mass m_0 of the block.

A. **Describe** an experimental procedure to collect data that would allow the students to determine m_0. Include any steps necessary to reduce experimental uncertainty.

B. **Describe** how the data collected in part A could be graphed and how that graph would be analyzed to determine m_0.

The students have an identical meterstick of mass M that is now attached to an axle that is fixed to a wall. The meterstick is free to rotate with negligible friction about the axle. The meterstick is suspended horizontally by a string that is connected to a spring scale of negligible mass, as shown in Figure 2.

Mock Reading Activity

Question 3

3. In Experiment 1, a student is given a resistor of unknown resistance and an air-filled parallel-plate capacitor of unknown capacitance. The student is asked to predict the expected time constant τ of a circuit if these two circuit elements were connected in series with a battery. The student has access to a battery of known emf, a switch, an ammeter, a ruler, and wires, as shown in Figure 1. The plates of the capacitor are square, and the separation between the plates is small compared to the dimensions of the plates. The capacitor is initially uncharged. Assume that the dielectric constant of air is 1.

Figure 1

| Resistor | Capacitor | Battery | Switch | Ammeter | Ruler | Wires |
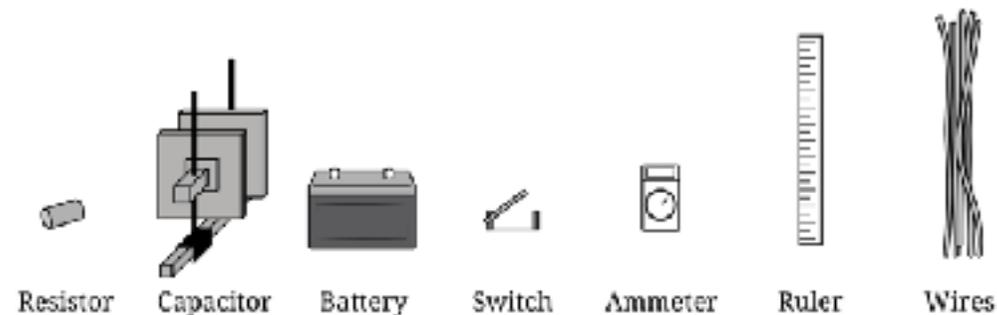
Note: Figure not drawn to scale.

A. **Describe** a procedure for collecting data that would allow the student to determine the expected time constant τ. In your description, include the measurements to be made. Include any steps necessary to reduce experimental uncertainty.

B. **Describe** how the collected data could be analyzed to determine τ. Include references to appropriate equations and to relationships between measured and known quantities.

Mock Reading Activity: Lab FRQ

- Find FRQ#3 in the Student Sample Packet
- Practice using the rubric to score several student samples.
- The purpose of this activity is to give you an idea of what the Reading is like and practice applying a rubric
- You will NOT agree with every decision made about how the rubric is applied, just to get a feel for the Reading