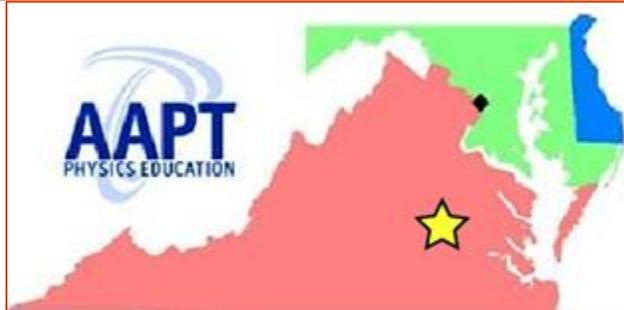


Standardizing exam versions for accurate assessment

- Finding the right proportion of concepts, problem-solving and medical applications



Chesapeake Section of the
American Association of Physics Teachers
Fall 2025 Semi-Virtual Meeting, October 11, 2025
@ Virginia Commonwealth University

Jency Sundararajan
University of Virginia

Background

Course: Physics 1 and 2 for Pre-health

Enrollment: 6 sections of 126 students each
(756 students)

Classroom: 15 round tables of 9 students at each table

Project – Summer 2025:

Uphold fairness while maintaining rigor and consistency across different exam versions, all while assessing the same learning objectives.



***5 UTAs/section
1 Grader/section
1 GTA/instructor***

Instructional Challenges

Three major factors impacting student performance:

- Allotted time (50 minutes)
- Difficulty level variations among different versions
- Weightage to the three parts
 - Part A (MCQ)
 - Part B (Conceptual question/ranking)
 - Part C (Multi-section problem solving)

	<i>Midterm 1 (50 points)</i>		<i>Midterm 2 (50 points)</i>		<i>Final Exam (100 points) – 3 hours</i>	
	<i>Versions</i>	<i>Format</i>	<i>Versions</i>	<i>Format</i>	<i>Versions</i>	<i>Format</i>
<i>Fall 2022 (50 minutes)</i>	9	5 Part A 4 Part B 2 Part C	6	3 Part C	6	15 Part A 5 Part B 6 Part C
<i>Fall 2023 (50 minutes)</i>	9	5 Part A 2 Part B 2 Part C	9	5 Part A 2 Part B 2 Part C	9	30 Part A 2 Part B 2 Part C
<i>Fall 2024 (50 minutes)</i>	5	15 Part A 1 Part B 1 Part C	5	15 Part A 1 Part B 1 Part C	5	40 Part A 1 Part C
<i>Spring 2023 (75 minutes)</i>	6	5 Part A 3 Part B 2 Part C	6	5 Part A 2 Part B 2 Part C	6	20 Part A 4 Part B 4 Part C
<i>Spring 2024 (75 minutes)</i>	6	5 Part A 2 Part B 2 Part C	6	5 Part A 2 Part B 2 Part C	5	35 Part A 2 Part C
<i>Spring 2025 (75 minutes)</i>	5	15 Part A 1 Part B	5	15 Part A 1 Part B	5	40 Part A 1 Part C

Aim of the Project

- *Maximizing the benefits of the different study resources utilized in the course.*
- *Creating a format that is ideal for finishing the exam within the specified timeframe.*
- *New exam format and creating five exam versions*

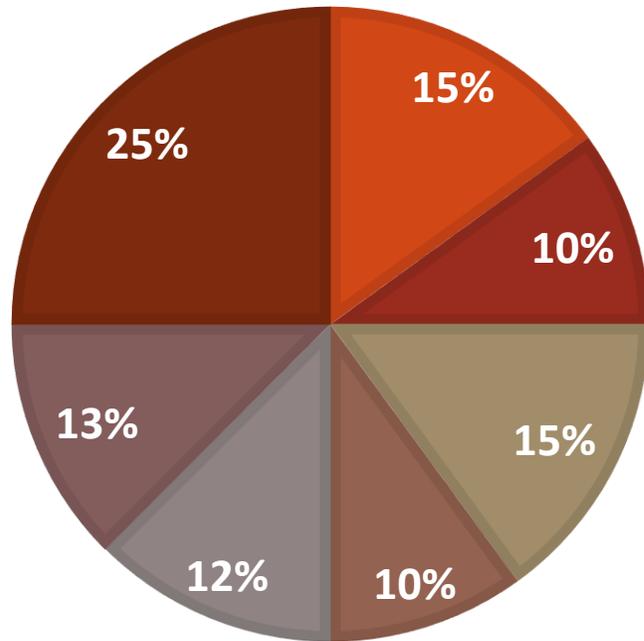
Exam Format – 60 Points

Question Type	Number of questions	Points per question	Points per part	Weightage
<u>Part A</u> Multiple choice questions	15	2	30	50%
<u>Part B</u> Conceptual questions/ranking	1	10	10	50 %
<u>Part C</u> Multi-section problem solving	1	20	20	
Total	17		60	100%

Course Activities and Management

COURSE ACTIVITIES

- In-class quizzes ■ Weekly quizzes ■ Homework
- Weekly report ■ Midterm 1 ■ Midterm 2
- Final Exam



Exams 50%

- Midterms (12.5% each) – 25%
- Final Exam – 25%

In-class (15%)	Outside the class (35%)
Poll Ev Quizzes(MCQ) (BOL/EOL)	Weekly quizzes (MCQ) Weekly report (Concepts)
Problems/concepts	Homework (Problems)

Parts Breakdown

Part A – Multiple Choice Question

Source	Number of questions	Percentage
BOL quizzes and worksheet	2	13.3%
Weekly quizzes	2	13.3%
Practice Midterm and Review	4	26.6%
New questions/question bank	3	20%
MCAT/PCAT/DAT style questions	4	26.6%
Total	15	100%

Part B – Conceptual Question/Ranking

Source	Number of questions	Percentage
Weekly report	1*	100%
Practice Midterm and Review	1*	
Worksheet	1*	
New questions/question bank	1*	
*Any ONE out of the 4 sources		
Total	1	100%

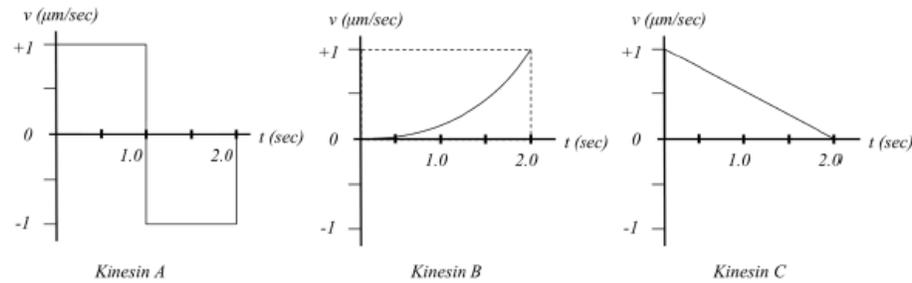
Part C – Multi-section Problem Solving

Source	Number of questions	Percentage
Homework	1*	100%
Practice Midterm and Review	1*	
Worksheet	1*	
New questions/question bank	1*	
*Any one out of the 4 sources		
Total	1	100%

Samples – Physics 1 – Part A

Version A

Cell biologists are investigating how kinesin motor proteins move along microtubules. The velocity of three different kinesin proteins (A, B, and C) was measured over a 2-second interval, as shown in the graphs below. Each kinesin begins at position $x=0$ and $t=0$. Based on the velocity–time graphs of Kinesin A, B, and C, what can you most likely conclude about the experiment?



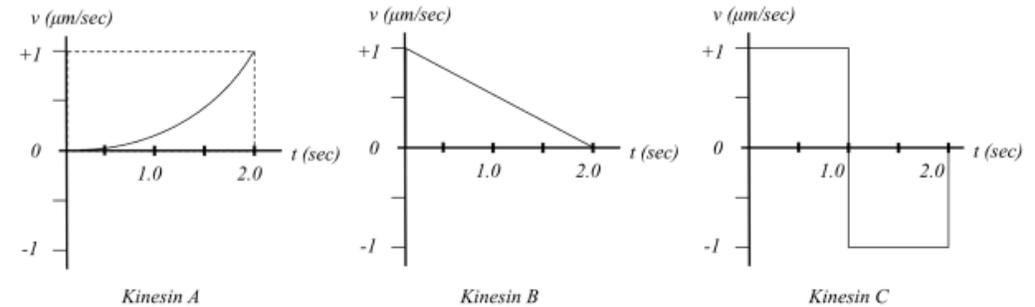
- A) Kinesin A reverses its direction of motion; Kinesin B continuously accelerates.
 B) Kinesin C maintains a constant velocity; Kinesin A reverses direction at $t=1.0$ s.
 C) Kinesin A and Kinesin C both return to their starting position at $t=2.0$ s.
 D) Kinesin C gradually slows down until stopping; Kinesin B moves at constant velocity.

During transcription, an RNA polymerase travels along DNA while adding nucleotides to a growing mRNA strand. In a particular in-vitro assay, the polymerase incorporates nucleotides at a rate of 90 nucleotides per second. X-ray studies show that nucleotides are spaced along DNA at 3.0 nucleotides per nanometer (i.e., 3 nucleotides / 1 nm). What is the speed of the RNA polymerase along the DNA (1 nanometer = 10^{-9} meters)?

- A. 3.0×10^{-7} m/s B. 3.0×10^{-8} m/s C. 3.0×10^{-9} m/s D. 3.0×10^{-10} m/s

Version B

Cell biologists are investigating how kinesin motor proteins move along microtubules. The velocity of three different kinesin proteins (A, B, and C) was measured over a 2-second interval, as shown in the graphs below. Each kinesin begins at position $x=0$ and $t=0$. Based on the velocity–time graphs of Kinesin A, B, and C, what can you most likely conclude about the experiment?



- A) Kinesin A continuously accelerates, while Kinesin B gradually slows to a stop.
 B) Kinesin B maintains constant velocity, while Kinesin C reverses direction at $t=1.0$ s.
 C) Kinesin B and Kinesin C both return to their starting position at $t=2.0$ s.
 D) Kinesin C slows down gradually, while Kinesin A moves at a constant velocity.

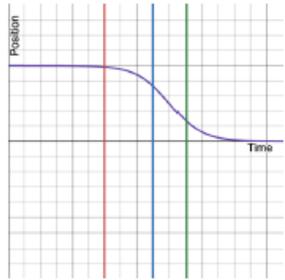
During transcription, an RNA polymerase travels along DNA while adding nucleotides to a growing mRNA strand. In a particular in-vitro assay, the polymerase incorporates nucleotides at a rate of 60 nucleotides per second. X-ray studies show that nucleotides are spaced along DNA at 3.0 nucleotides per nanometer (i.e., 3 nucleotides / 1 nm). What is the speed of the RNA polymerase along the DNA (1 nanometer = 10^{-9} meters)?

- A. 2.0×10^{-7} m/s B. 2.0×10^{-8} m/s C. 2.0×10^{-9} m/s D. 2.0×10^{-10} m/s

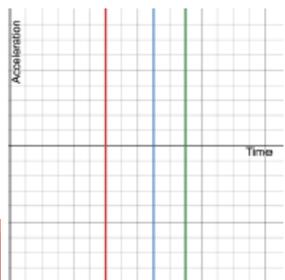
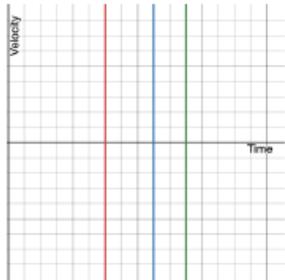
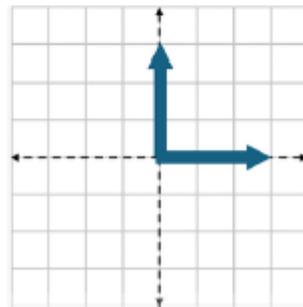
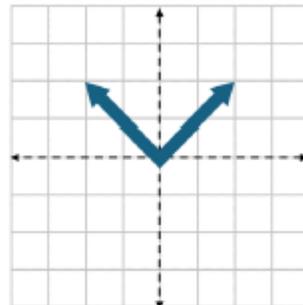
Samples - Physics 1 - Part B

Version A

Given the following position-time graph, draw a rough sketch of the velocity-time and acceleration-time graphs in the space provided. Assume constant acceleration during each segment of motion.

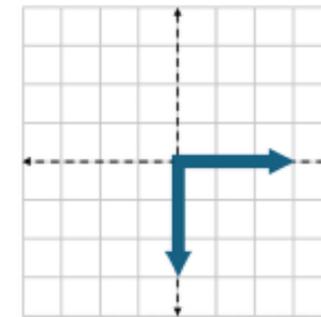
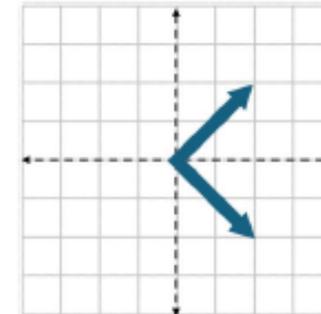
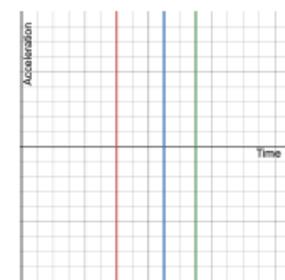
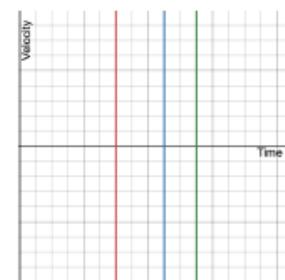
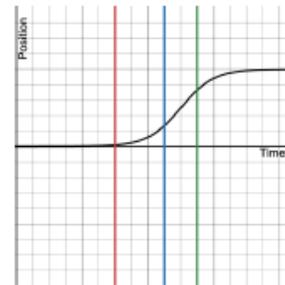


2. For each of the following free body diagrams, draw one additional vector to place the object in translational equilibrium.



Version B

2. For each of the following free body diagrams, draw one additional vector to place the object in translational equilibrium.



Samples – Physics 2 – Part A

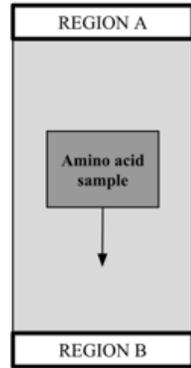
VERSION A

During isoelectric focusing, a mixture of amino acids is placed in a gel that contains a stable electric field across it. A particular amino acid has a net negative charge at physiological pH and is introduced at the center of the strip. Region A (top) and Region B (bottom) act like the plates of a parallel plate capacitor, establishing a uniform electric field through the gel between them.

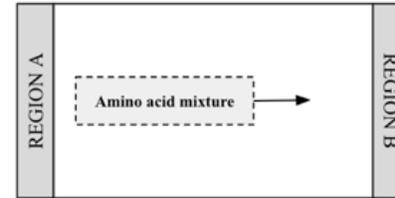
As the electric field is applied, the amino acid moves downward toward Region B.

Based on the movement of the negatively charged amino acid, which of the following conclusions can be drawn about the electric field and the electric potential of the regions?

- A) The electric field points upward, and Region B is at lower electric potential.
- B) The electric field points downward, and Region B has a higher electric potential.
- C) The electric field points upward, and Region A has a lower electric potential.
- D) The electric field points downward, and Region A has a higher electric potential.



VERSION B



In a technique called isoelectric focusing, amino acids are placed in a gel that contains a stable electric field across it. A particular amino acid has a net positive charge at physiological pH and is introduced at the center of the strip. Region A (left) and Region B (right) act like the plates of a parallel plate capacitor, establishing a uniform electric field through the gel between them.

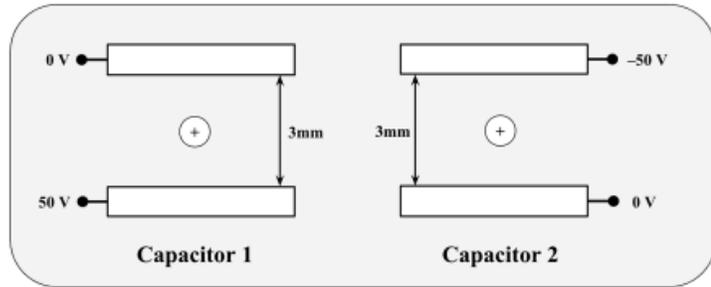
As the electric field is applied, the amino acid moves to the right toward Region B.

Based on the movement of the positively charged amino acid, which of the following conclusions can be drawn about the electric field and the electric potential of the regions?

- A) The amino acid sample is moving in the same direction as the electric field, and Region A is at a higher electric potential.
- B) The amino acid sample is moving in the opposite direction as the electric field, and Region A is at a lower electric potential.
- C) The amino acid sample is moving in the same direction as the electric field, and Region B is at a higher electric potential.
- D) The amino acid sample is moving in the opposite direction as the electric field, and Region B is at a lower electric potential.

Samples – Physics 2 – Part B

Version A

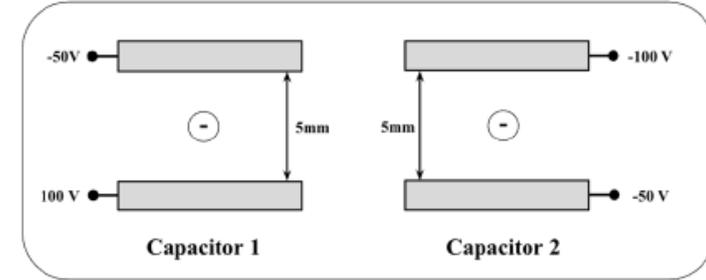


The figure shows two capacitors, each with a 3mm separation. A proton is released from rest in the center of each capacitor.

- Draw an arrow on each proton to show the direction they move.
- Circle the plate with the higher electric potential of each capacitor.
- Which proton reaches the capacitor plate first (check below)? Explain why.

Capacitor 1
 Capacitor 2
 Simultaneous

Version B



The figure shows two capacitors, each with a 5mm separation. An electron is released from rest in the center of each capacitor.

- Draw an arrow on each electron to show the direction they move.
- Draw the uniform electric field lines between the plates of each capacitor.
- Which electron reaches the capacitor plate first (check below)? Explain why.

Capacitor 1
 Capacitor 2
 Simultaneous

Midterm 1 - Survey

Midterm 1 - Difficulty



Response options	Count	Percentage
The exam was fair	48	43%
Part A was hard	45	41%
Part B was hard	2	2%
Part C was hard	16	14%

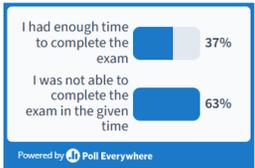


Engagement

111

Responses

Midterm 1 - allotted time



Response options	Count	Percentage
I had enough time to complete the exam	40	37%
I was not able to complete the exam in the given time	67	63%

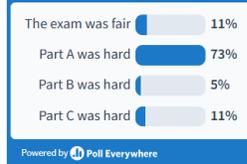


Engagement

107

Responses

Midterm 1 - Difficulty



Response options	Count	Percentage
The exam was fair	13	11%
Part A was hard	83	73%
Part B was hard	6	5%
Part C was hard	12	11%

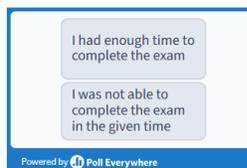


Engagement

114

Responses

Midterm 1 - allotted time



Response options	Count	Percentage
I had enough time to complete the exam	38	35%
I was not able to complete the exam in the given time	71	65%



Engagement

109

Responses

Fall 2025 – Midterm 1 stats

Midterm 1 - Multiple Choice Performance - Professor Jency's Class			
Metric	Fall 2024	Fall 2025	Change ('25 – '24)
Total Students	330	381	
Average Score (Mean)	24.09 / 30 ($\approx 80.3\%$)	22.28 / 30 ($\approx 74.3\%$)	-1.81 pts (-6%)
Median Score	25.3 / 30 ($\approx 84.33\%$)	23.3 ($\approx 77.67\%$)	-2.0 pts
Minimum Score (avg across sections)	≈ 7.3	≈ 5.3	-2.0 pts
Maximum Score	30.0	30.0	0

Midterm 1 - Free Response Performance - Professor Grouchy's Class						
Version	Part B (%)	Δ vs Avg (B)	Part C (%)	Δ vs Avg (C)	Total (%)	Δ vs Avg (Total)
A	66.2 %	-0.4 pts ($\approx -0.6\%$)	74.0 %	-6.4 pts ($\approx -7.9\%$)	71.4 %	-4.1 pts ($\approx -5.4\%$)
B	67.6 %	+1.0 pts ($\approx +1.5\%$)	80.0 %	-0.4 pts ($\approx -0.5\%$)	75.9 %	+0.4 pts ($\approx +0.6\%$)
C	62.2 %	-4.4 pts ($\approx -6.6\%$)	87.0 %	+6.6 pts ($\approx +8.2\%$)	78.7 %	+3.8 pts ($\approx +5.1\%$)
D	66.6 %	0.0 (= avg)	76.0 %	-4.4 pts ($\approx -5.5\%$)	72.9 %	-2.5 pts ($\approx -3.3\%$)
E	60.6 %	-6.0 pts ($\approx -9.0\%$)	75.0 %	-5.4 pts ($\approx -6.7\%$)	70.2 %	-4.7 pts ($\approx -6.3\%$)
Mean (all)	66.6 %	—	80.4 %	—	75.6 %	—

Fall 2025 – Midterm 1 stats

Key Findings

Part A (Multiple Choice)

- Average scores decreased by about 6% compared to Fall 2024.
- Performance across versions remained consistent, which indicates strong version parity.
- However, the questions were too multi-layered and complex, which likely contributed to the lower averages.

Part B (Short Free Response)

- Assessed multiple concepts, but three sub-questions made time management challenging.
- Noticeable differences in difficulty between versions ($\approx 9\%$ range).

Part C (Long Free Response)

- Largest disparity across versions — up to a 13% difference between the easiest (Version C) and hardest (Version E).
- The variation stems primarily from site-specific content differences.

Acknowledgement

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Prof. Maxim Bychkov

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