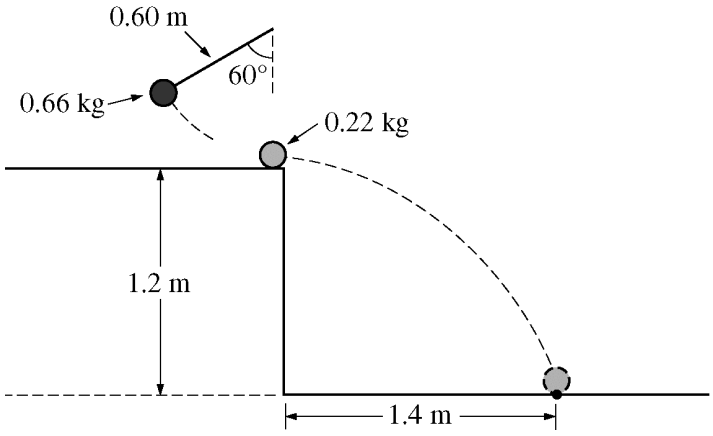
PHYSICS B

SECTION II

Time—90 minutes

6 Questions

Directions: Answer all six questions, which are weighted according to the points indicated. The suggested times are about 17 minutes for answering each of Questions 1-4 and about 11 minutes for answering each of Questions 5-6. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part.



1. (15 points)

The experimental apparatus shown in the figure above contains a pendulum consisting of a 0.66 kg ball attached to a string of length 0.60 m. The pendulum is released from rest at an angle of $60°$ and collides with a ball of mass 0.22 kg initially at rest at the edge of a table. The 0.22 kg ball hits the floor a distance of 1.4 m from the edge of the table.

(a) Calculate the speed of the 0.66 kg ball just before the collision.

GO ON TO THE NEXT PAGE.

(b) Calculate the speed of the 0.22 kg ball immediately after the collision.

(c) Calculate the speed of the 0.66 kg ball immediately after the collision.

(d) Indicate the direction of motion of the 0.66 kg ball immediately after the collision.

____ To the left ____ To the right

(e) Calculate the height to which the 0.66 kg ball rises after the collision.

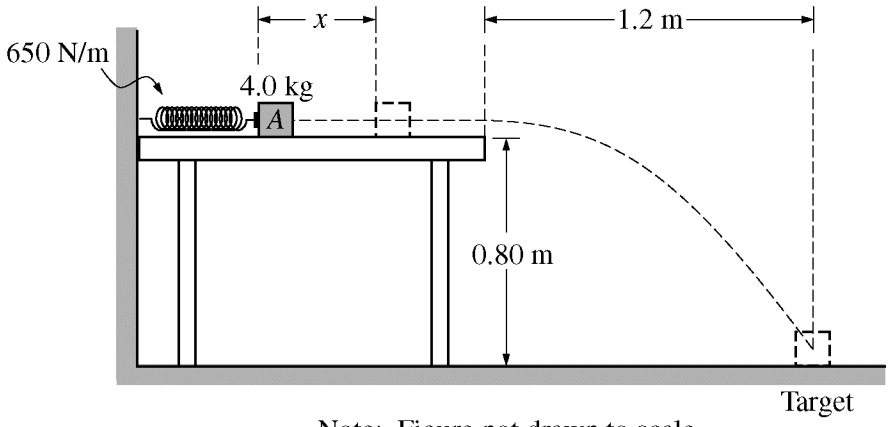
(f) Based on your data, is the collision elastic?

____ Yes ____ No

Justify your answer.

PHYSICS B
SECTION II
Time—90 minutes
7 Questions

Directions: Answer all seven questions, which are weighted according to the points indicated. The suggested times are about 17 minutes for answering each of Questions 1-2 and about 11 minutes for answering each of Questions 3-7. The parts within a question may not have equal weight. Show all your work in the pink booklet in the spaces provided after each part, NOT in this green insert.



Note: Figure not drawn to scale.

1. (15 points)

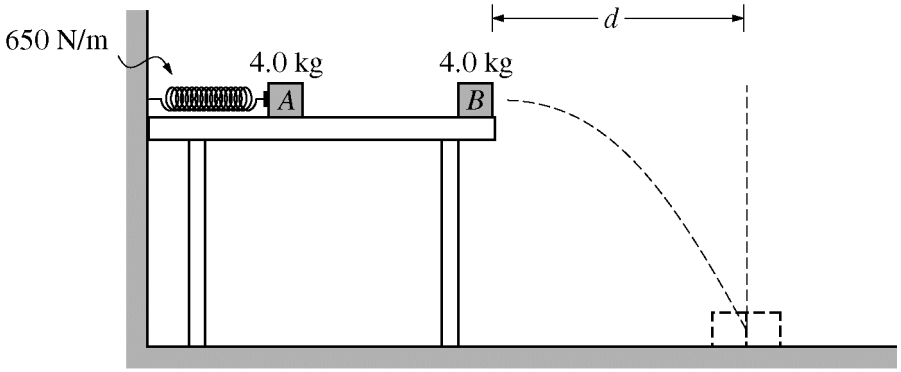
Block *A* of mass 4.0 kg is on a horizontal, frictionless tabletop and is placed against a spring of negligible mass and spring constant $650\ \text{N/m}$. The other end of the spring is attached to a wall. The block is pushed toward the wall until the spring has been compressed a distance *x*, as shown above. The block is released and follows the trajectory shown, falling 0.80 m vertically and striking a target on the floor that is a horizontal distance of 1.2 m from the edge of the table. Air resistance is negligible.

(a) Calculate the time elapsed from the instant block *A* leaves the table to the instant it strikes the floor.

(b) Calculate the speed of the block as it leaves the table.

(c) Calculate the distance *x* the spring was compressed.

Block *B*, also of mass 4.0 kg, is now placed at the edge of the table. The spring is again compressed a distance *x*, and block *A* is released. As it nears the end of the table, it instantaneously collides with and sticks to block *B*. The blocks follow the trajectory shown in the figure below and strike the floor at a horizontal distance *d* from the edge of the table.



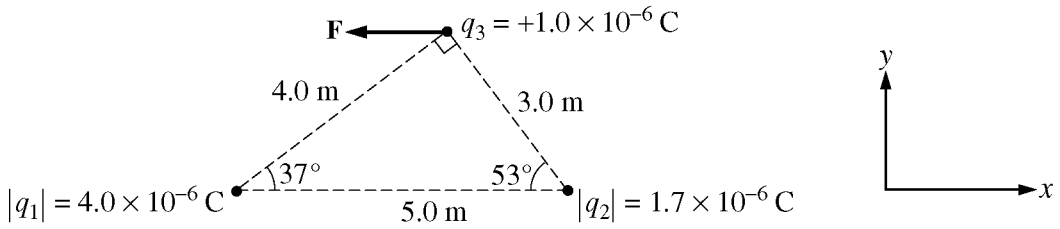
Note: Figure not drawn to scale.

(d) Calculate d if x is equal to the value determined in part (c).

(e) Consider the system consisting of the spring, the blocks, and the table. How does the total mechanical energy E_2 of the system just before the blocks leave the table compare to the total mechanical energy E_1 of the system just before block A is released?

____ $E_2 < E_1$ ____ $E_2 = E_1$ ____ $E_2 > E_1$

Justify your answer.



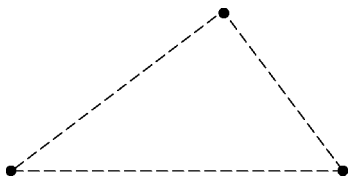
3. (10 points)

Three particles are fixed in place in a horizontal plane, as shown in the figure above. Particle 3 at the top of the triangle has charge q_3 of $+1.0 \times 10^{-6}$ C, and the electrostatic force **F** on it due to the charge on the two other particles is measured to be entirely in the negative *x*-direction. The magnitude of the charge q_1 on particle 1 is known to be 4.0×10^{-6} C, and the magnitude of the charge q_2 on particle 2 is known to be 1.7×10^{-6} C, but their signs are not known.

(a) Determine the signs of the charges q_1 and q_2 and indicate the correct signs below.

q_1	____ Negative	q_2	____ Negative
	____ Positive		____ Positive

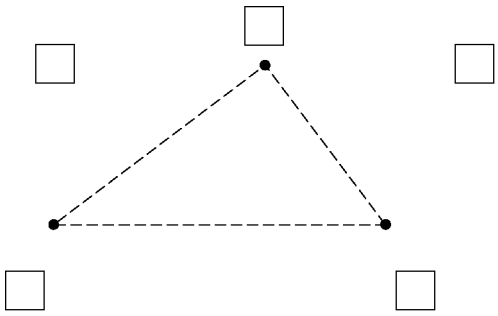
(b) On the diagram below, draw and label arrows to indicate the direction of the force F_1 exerted by particle 1 on particle 3 and the force F_2 exerted by particle 2 on particle 3.



(c) Calculate the magnitude of **F**, the electrostatic force on particle 3.

(d) Calculate the magnitude of the electric field at the position of particle 3 due to the other two particles.

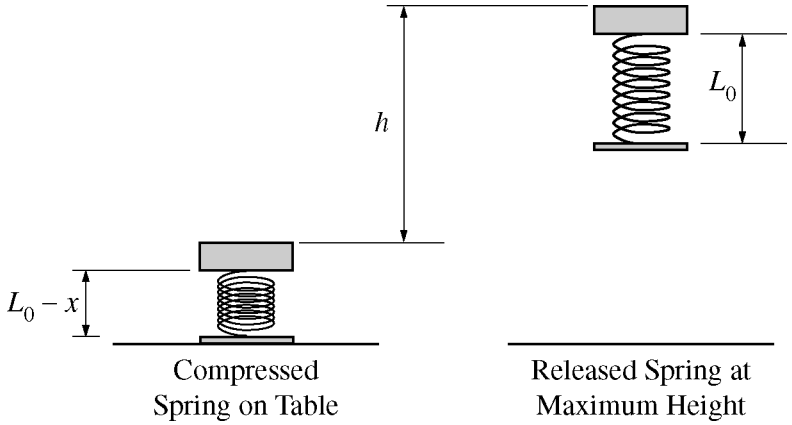
(e) On the figure below, draw a small × in the box that is at a position where another positively charged particle could be fixed in place so that the electrostatic force on particle 3 is zero.



Justify your answer.

PHYSICS B
SECTION II
Time—90 minutes
7 Questions

Directions: Answer all seven questions, which are weighted according to the points indicated. The suggested times are about 17 minutes for answering each of Questions 1 and 3 and about 11 minutes for answering each of Questions 2 and 4-7. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part, NOT in the green insert.



1. (15 points)

In an experiment, students are to calculate the spring constant k of a vertical spring in a small jumping toy that initially rests on a table. When the spring in the toy is compressed a distance x from its uncompressed length L_0 and the toy is released, the top of the toy rises to a maximum height h above the point of maximum compression. The students repeat the experiment several times, measuring h with objects of various masses taped to the top of the toy so that the combined mass of the toy and added objects is m. The bottom of the toy and the spring each have negligible mass compared to the top of the toy and the objects taped to it.

(a) Derive an expression for the height h in terms of m, x, k, and fundamental constants.

With the spring compressed a distance $x = 0.020$ m in each trial, the students obtained the following data for different values of m.

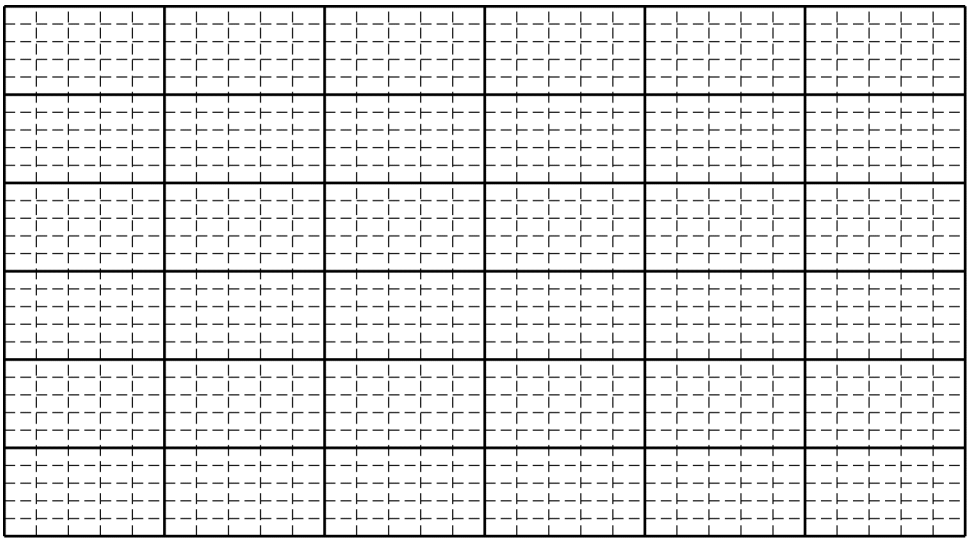
	m (kg)	h (m)	
	0.020	0.49	
	0.030	0.34	
	0.040	0.28	
	0.050	0.19	
	0.060	0.18	

(b)

i. What quantities should be graphed so that the slope of a best-fit straight line through the data points can be used to calculate the spring constant k ?

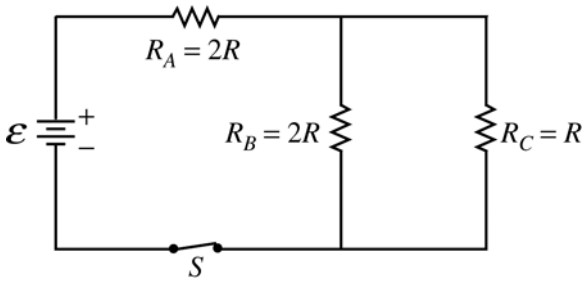
ii. Fill in one or both of the blank columns in the table with calculated values of your quantities, including units.

(c) On the axes below, plot your data and draw a best-fit straight line. Label the axes and indicate the scale.



(d) Using your best-fit line, calculate the numerical value of the spring constant.

(e) Describe a procedure for measuring the height h in the experiment, given that the toy is only momentarily at that maximum height.



3. (15 points)

The circuit above contains a battery with negligible internal resistance, a closed switch *S*, and three resistors, each with a resistance of *R* or 2*R*.

(a)

i. Rank the currents in the three resistors from greatest to least, with number 1 being greatest. If two resistors have the same current, give them the same ranking.

____ I_A ____ I_B ____ I_C

ii. Justify your answers.

(b)

i. Rank the voltages across the three resistors from greatest to least, with number 1 being greatest. If two resistors have the same voltage across them, give them the same ranking.

____ V_A ____ V_B ____ V_C

ii. Justify your answers.

For parts (c) through (e), use $\mathcal{E}$ = 12 V and $R = 200\ \Omega$.

(c) Calculate the equivalent resistance of the circuit.

(d) Calculate the current in resistor R_C.

(e) The switch *S* is opened, resistor R_B is removed and replaced by a capacitor of capacitance 2.0×10^{-6} F, and the switch *S* is again closed. Calculate the charge on the capacitor after all the currents have reached their final steady-state values.