

Question 3

3. A box is connected to one end of a rigid rod. Both the box and the rod have negligible mass. The other end of the rod is connected to a pivot. The box is open on one side, and a block is placed inside the box.

The center of mass of the block is displaced a vertical distance  $h$ , as shown in Figure 1. The block-box system is then released from rest and swings downward. There is negligible friction about the pivot. When the system is at the lowest point of its swing, the rod collides with a rigid stopper, as shown in Figure 2. The box comes to rest, and the block is launched horizontally out of the box. The block moves across a horizontal surface toward a motion sensor that measures the speed of the block. All frictional forces are negligible.

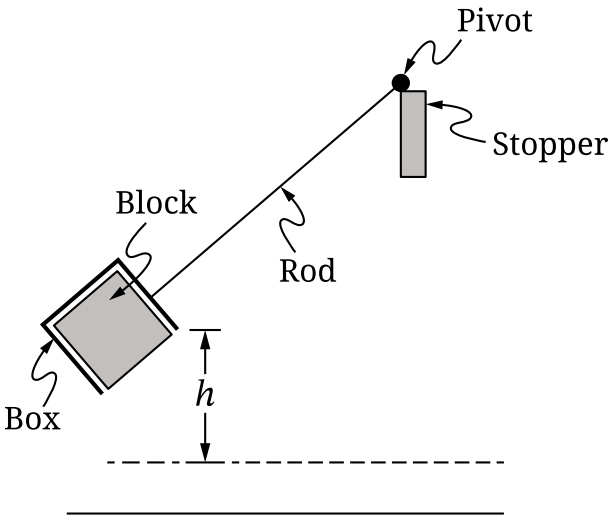


Figure 1

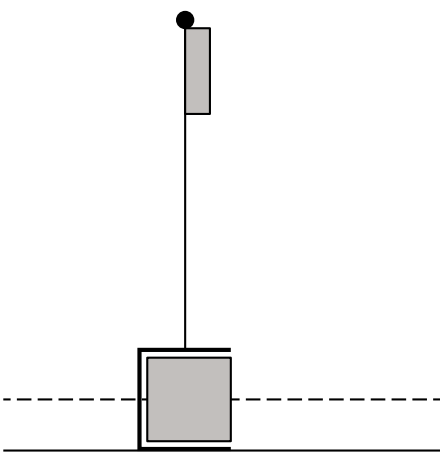


Figure 2

- A. Students are asked to experimentally determine the acceleration due to gravity  $g$  using a linear graph. To determine  $g$ , the students are permitted to use measurements from only a meterstick and the motion sensor.
- Describe** an experimental procedure using the described setup to collect data that would allow the students to determine an experimental value of  $g$  using a linear graph. 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 the value of  $g$ .

C. The experiment is repeated, but the horizontal surface on which the block slides is replaced with a new rough surface, as shown in Figure 3. The coefficient of kinetic friction between the block and the new surface is  $\mu$ .

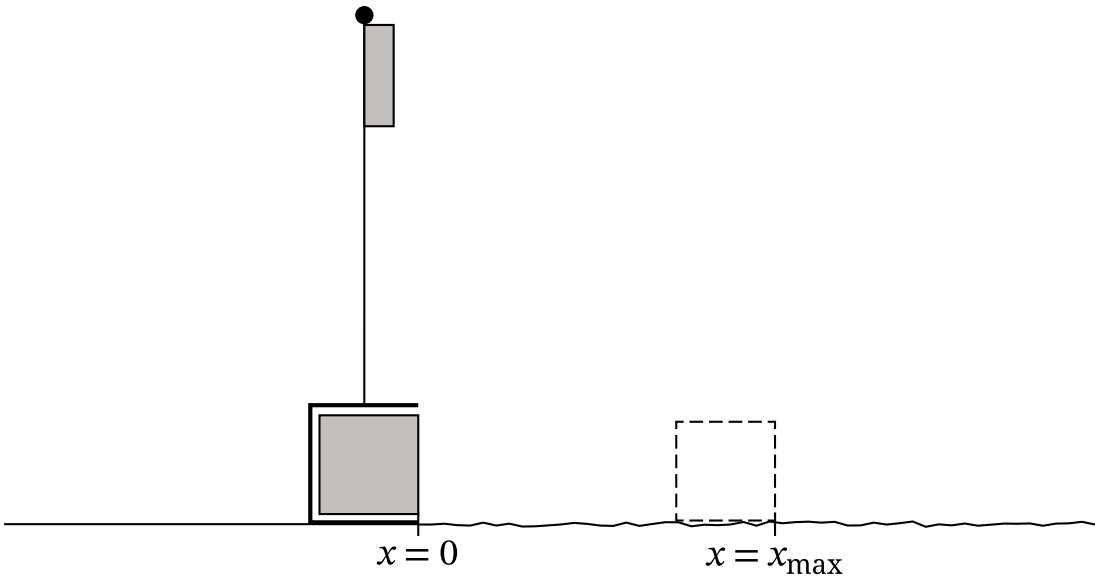


Figure 3

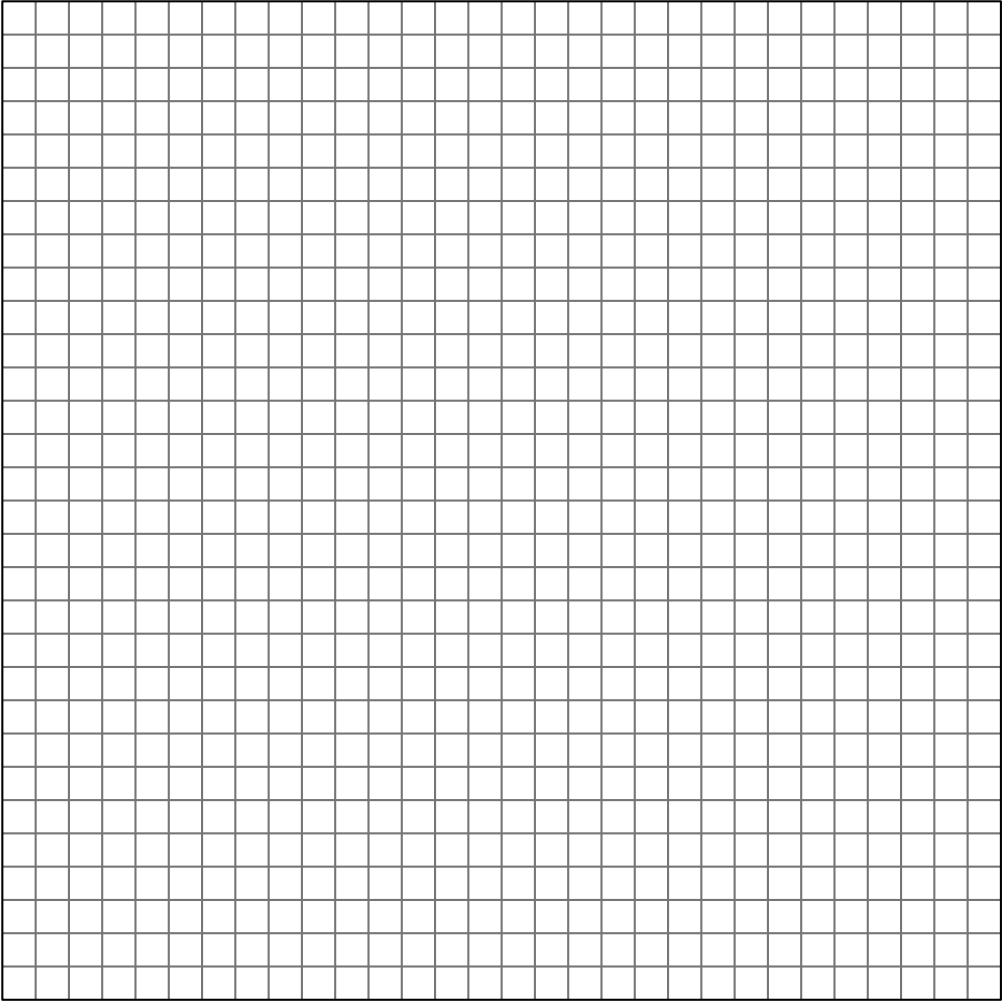
The block-box system is pulled aside so that the center of mass of the block is displaced various vertical distances  $h$  and then released from rest. For each vertical distance, students measure the position  $x = x_{\text{max}}$  at which the block comes to rest. The students' measurements of  $h$  and  $x_{\text{max}}$  are shown in Table 1.

Table 1

| $h$ (m) | $x_{\text{max}}$ (m) |
|---------|----------------------|
| 0.30    | 0.76                 |
| 0.45    | 1.10                 |
| 0.60    | 1.40                 |
| 0.75    | 1.90                 |
| 0.90    | 2.30                 |

- i. **Indicate** two quantities, either measured quantities from Table 1 or additional calculated quantities, that could be graphed to produce a straight line that could be used to determine  $\mu$ .
- Vertical axis: \_\_\_\_\_ Horizontal axis: \_\_\_\_\_

- ii. On the grid provided, create a graph of the quantities indicated in part C (i).
- Use Table 2 to record the measured or calculated quantities that you will plot.
  - Clearly **label** the axes, including units as appropriate.
  - Plot** the points you recorded in Table 2.



- iii. **Draw** a best-fit line to the data graphed in part C (ii).
- D. Using the best-fit line that you drew in part C (iii), **calculate** an experimental value for  $\mu$ .