PHYSICS C: MECHANICS
SECTION II
Time—45 minutes
3 Questions

Directions: Answer all three questions. The suggested time is about 15 minutes for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part.

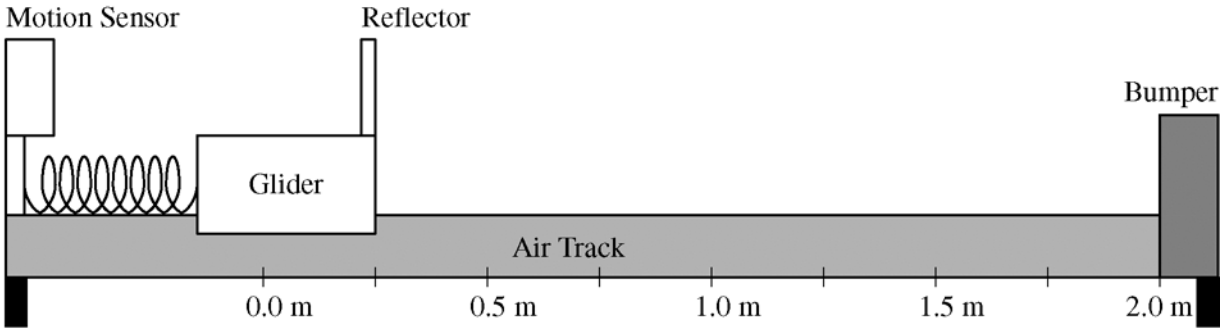

Figure 1

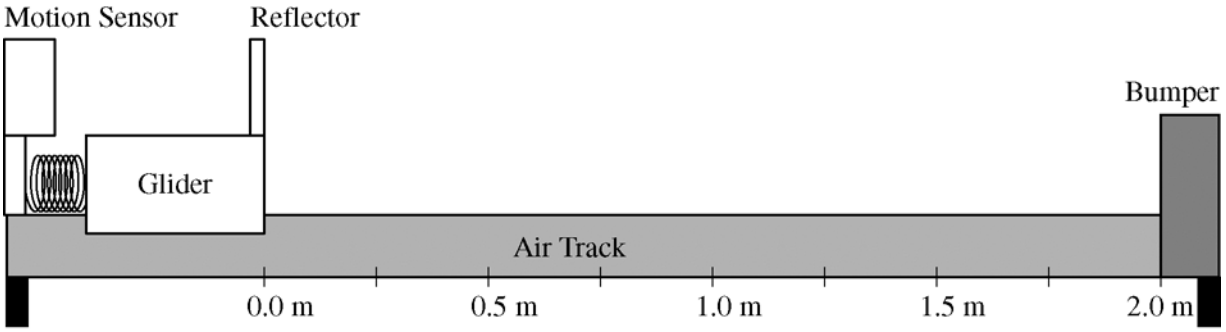

Figure 2

Mech 1.

A student places a 0.40 kg glider on an air track of negligible friction and holds it so that it touches an uncompressed ideal spring, as shown in Figure 1 above. The student then pushes the glider back to compress the spring by 0.25 m, as shown in Figure 2. At time $t = 0$, the student releases the glider, and a motion sensor begins recording the velocity of the reflector at the front of the glider as a function of time. The data points are shown in the table below. At time $t = 0.79$ s, the glider loses contact with the spring.

Time (s)	0	0.25	0.50	0.75	1.00	1.50	2.00
Velocity (m/s)	0	0.25	0.43	0.48	0.50	0.49	0.51

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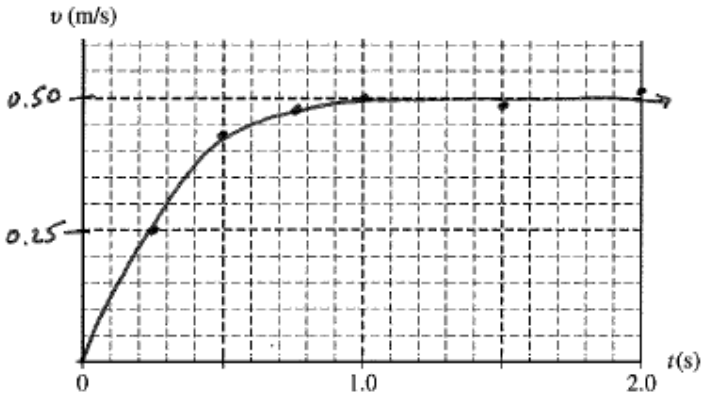
Question 1

15 points total **Distribution of points**

(a) 3 points



For labeling the axes with appropriate values 1 point
For a smooth curve that begins with increasing v and is concave down 1 point
For a horizontal line near $v = 0.50\ \text{m/s}$, beginning between t = 0.79 and 1.0 s 1 point

(b)

i. 1 point

For a correct method of plotting position x as a function of time t 1 point

Examples

Plot the area under the velocity curve from part (a) as a function of time.

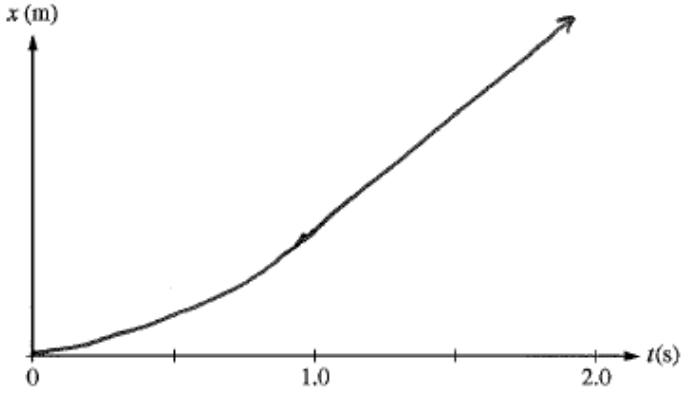
$x = \int v dt$

The slope of x as a function of t would yield the v versus t graph in part (a).

Question 1 (continued)

Distribution of points

ii. 3 points



For a smooth curve that begins with increasing x and is concave up for $t < 0.79$ s, ending between $t = 0.79$ s and 1.0 s — 1 point

For a straight line with a positive slope, beginning between $t = 0.79$ s and 1.0 s — 1 point

For a smooth transition of the curve from non-linear to linear in the region between $t = 0.79$ s and 1.0 s — 1 point

(c) 3 points

For using the graph to determine the distance traveled during the first part of the motion, beginning at $t = 0$ and ending somewhere between 0.79 s (when the glider and spring lose contact) and 2 s (the maximum time shown on the velocity graph — 1 point

For calculating using the graph between 0 and 1.0 s,

$d_1 \approx (2.9 \text{ large grid squares})(0.125 \text{ m/square}) = 0.36 \text{ m}$

(1 square = 0.25 m/s × 0.5 s = 0.125 m)

For a correct expression indicating constant velocity during the last part of the motion — 1 point

$d_2 = v\Delta t = v(t - 1.0 \text{ s})$

For adding the two distances and solving for the time at which the glider hits the bumper — 1 point

$d_1 + d_2 = 2.0 \text{ m}$

$0.36 \text{ m} + (0.50 \text{ m/s})(t - 1.0 \text{ s}) = 2.0 \text{ m}$

$t = \dfrac{(2.0 - 0.36) \text{ m}}{0.50 \text{ m/s}} + 1.0 \text{ s} = 4.3 \text{ s}$

Question 1 (continued)

Distribution of points

Alternate Solution

Alternate Points

For using the given information about the spring compression and the time at which the glider loses contact with the spring to arrive at $t_1 = 0.79$ s *at* $d_1 = 0.25$ m — *1 point*

$d_2 = 2.0 \text{ m} - 0.25 \text{ m} = 1.75 \text{ m}$

For a correct expression indicating constant velocity during the last part of the motion — *1 point*

$t_2 = d_2/v = 1.75 \text{ m}/0.50 \text{ m/s} = 3.5 \text{ s}$

For adding the two times — *1 point*

$t = t_1 + t_2 = 0.79 \text{ s} + 3.5 \text{ s}$

$t = t_1 + t_2 = 4.29 \text{ s}$

(d) 2 points

For a correct expression of conservation of energy in terms of the spring constant k and the velocity v — 1 point

$U_{S1} = K_2$

$\frac{1}{2}kx_1^2 = \frac{1}{2}mv_2^2$

$k = \frac{mv_2^2}{x_1^2}$

$k = \frac{mv_2^2}{x_1^2} = \frac{(0.40 \text{ kg})(0.50 \text{ m/s})^2}{(0.25 \text{ m})^2}$

For a correct answer, with correct units — 1 point

$k = 1.6 \text{ N/m}$

Question 1 (continued)

Distribution of points

(e)

i. 1 point

For the correct amplitude — 1 point

$x_m = 0.25 \text{ m}$

ii. 2 points

For some work that uses a correct expression for the period of a spring — 1 point

$T = 2\pi\sqrt{\frac{m}{k}}$

For correct substitution of consistent values — 1 point

$T = 2\pi\sqrt{\frac{(0.40 \text{ kg})}{(1.6 \text{ N/m})}} = 3.1 \text{ s}$

Alternate Solution — *Alternate Points*

For recognizing that the 0.79 s of contact time is one quarter of a period — *1 point*

For giving the period as four times the contact time — *1 point*

$T = 4(0.79 \text{ s}) = 3.2 \text{ s}$