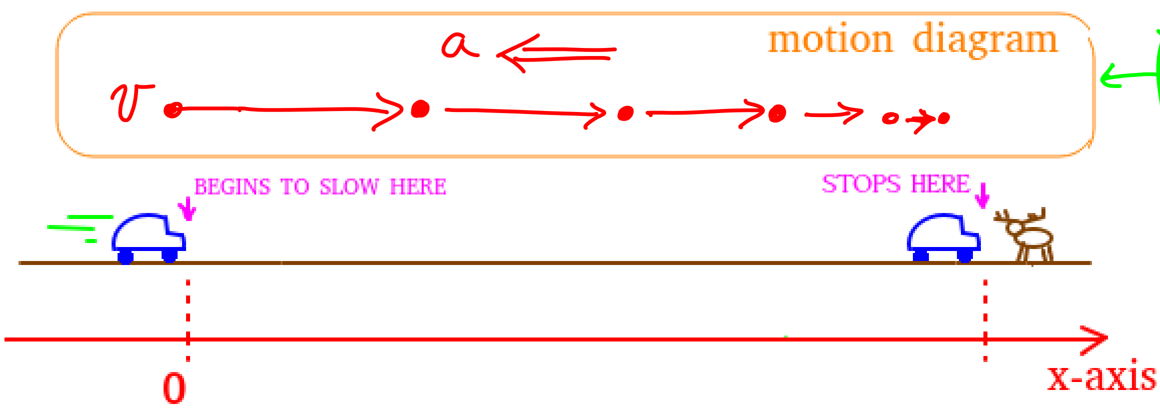
 ANSWER KEY

Group Number: Names:

Date:

Show all work. If you don't have enough room on this document, you can add pages.

(1) [15 total] A car is traveling along a straight and level road to the right, initially moving with a speed of 31.3 m/s, and slowing down until it stops. Suppose the acceleration has a constant magnitude of $4.50\,\mathrm{m/s^2}$. This could be, for example, a panic braking to stop before hitting a deer standing in the road. We take Event 0 at $t_0 = 0.00\,\mathrm{s}$ to be the instant the car begins to slow down, reaction time is not considered in this problem. Use the coordinate system and other problem fragments given in the diagram below. The list of tasks follows.



sequence of v arrows, and one a arrow

tabulation of kinematic quantities →

Event 0

$t_0 = 0\ \mathrm{s}$

$x_0 = 0\ \mathrm{m}$

$v_0 = 31.3\ \frac{\mathrm{m}}{\mathrm{s}}$

$a_{01} = -4.50\ \frac{\mathrm{m}}{\mathrm{s}^2}$

(a points opposite x-axis)

Event 1

$t_1 =$ 6.96 s

$x_1 =$ 109 m

$v_1 =$ 0 m/s ← car stops

← unknowns (solved on next page)

/½ **(1.a)** Construct a qualitative motion diagram in the space provided above.

/5 **(1.b)** Tabulate the kinematic quantities listed in the diagram above. Use empty boxes to indicate the unknowns. How many unknowns are there?

number of unknowns: 2

do you see the (initially) empty boxes above?

/2 **(1.c)** For each unknown, write down an end-of-the-chapter style question. (Answers can vary)

t_1: how long does it take for the car to stop?

answer: It took 6.96 seconds to stop.

x_1: how far does the car move while stopping?

answer: The car traveled 109 m or 358 feet while stopping.

/6 **(1.d)** Using your tabulated kinematic quantities, fill in the three kinematic equations linking the two events and simplify algebraically to either solve for the unknowns or validate the data. Complete all three equations. (If you use maxima or another program to numerically solve, indicate what you did.)

use $t_1 - t_0 = t_1 - (0) = t_1$

follow steps

(1)
$$x_1 = x_0 + v_0 \cdot (t_1 - t_0) + \frac{1}{2} a_{01} \cdot (t_1 - t_0)^2$$

$x_1 = (0) + (31.3)\, t_1 + \frac{1}{2}(-4.50)\, t_1^2$ ← includes two unknowns

(5) $x_1 = (0) + (31.3)(6.96) + \frac{1}{2}(-4.50)(6.96)^2$

(6) $= (108.85\ldots) = \boxed{109\text{ m}}$ ← found this value.

$$v_1 = v_0 + a_{01} \cdot (t_1 - t_0)$$

(2) $(0) = (31.3) + (-4.50)\, t_1$ ← includes one unknown (so solve for it)

(3) $(4.50)\, t_1 = (31.3)$

(4) $t_1 = \dfrac{(31.3)}{(4.50)} = (6.955\ldots) = \boxed{6.96\text{ s}}$ ← found t_1

$$v_1^2 = v_0^2 + 2\, a_{01} \cdot (x_1 - x_0)$$

(7) $(0)^2 \stackrel{?}{=} (31.3)^2 + 2(-4.50)(109 - 0)$

(8) $0 \stackrel{?}{=} (980) - (981) = -1$ ✓

[note that we rounded some number so we won't have equality, but 1 can be compared to 980, which is about 0.1% error.]

/1½ **(1.e)** Fill in the empty boxes in your diagram and answer your end-of-the-chapter questions (using written words). Then (to develop an intuition) convert the initial speed and stopping distance into more familiar units of MPH and feet.

$31.3 \frac{m}{s} \times \left(\frac{3600 s}{hr}\right) \times \left(\frac{mi}{1609 m}\right) = 70.0$ MPH ← miles/hour

$|v_0| = 31.3\,\text{m/s} =$ 70.0 MPH

$|x_1 - x_0| =$ 109 m = 358 feet

$109 m \times \frac{1 in}{2.54 cm} \times \frac{100 cm}{m} \times \frac{ft}{12 in} = 358$ ft

⋆ Go back and review your answers for consistency and ensure numerical results have the correct signs, significant figures, and units.