1 At time $t = 0$ two persons entered the elevator of the tower shown in Fig. E2.3. The first person rode to the restaurant level. The second person went to the observation deck. Plot the time–elevation and the velocity–elevation diagrams for each of the two persons considering that the elevator started up 3 s after they entered, made no intermediate stops between the ground and the restaurant levels, and stayed for 6 s at the restaurant level. The elevator manufacturer's brochure provides the following technological specifications: acceleration is 5 ft/s^2; deceleration is 4 ft/s^2; and maximum cruising velocity is 20 ft/s.

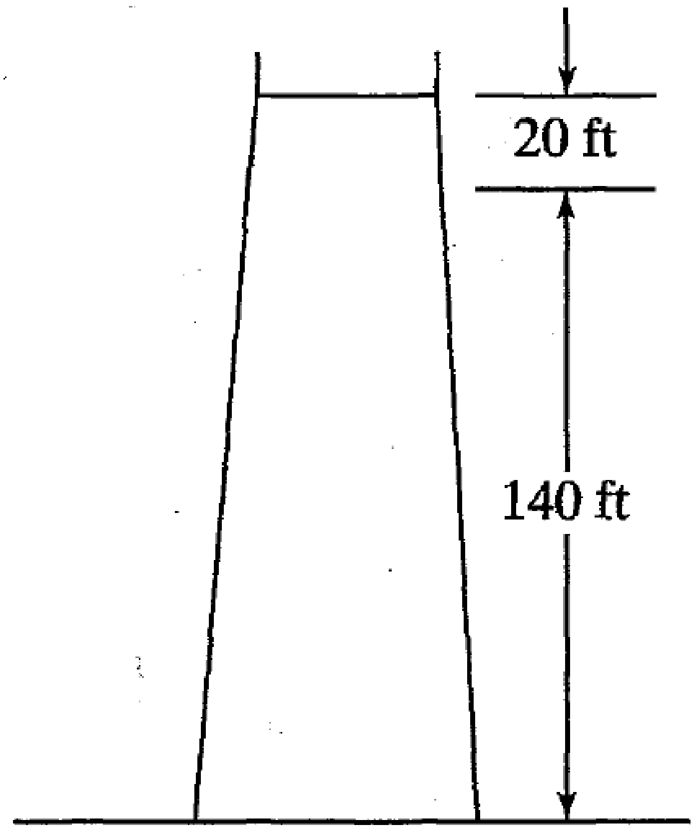


Figure E2.3

Assuming the case of constant acceleration,

$$v = at + v_0 \quad \text{and} \quad (v^2 - v_0^2) = 2a(x - x_0)$$

The movement from the ground floor to the restaurant level involved:

Total distance = 140 ft.

Time to reach cruising velocity when a = 5 ft/s^2 = $\frac{20}{5}$ = 4 s.

Time to stop from cruising velocity when d = 4 ft/s^2 = $\frac{20}{4}$ = 5 s.

Acceleration distance = $20^2/[2(5)]$ = 40 ft.

Deceleration distance = $20^2/[2(4)]$ = 50 ft.

Cruising distance = 140 - 40 - 50 = 50 ft.

Cruising time at maximum cruising speed = 50/20 = 2.5 s.

During the movement from the restaurant level to the observation deck the elevator did not reach cruising velocity. The total distance of 20 ft consisted of accelerating (x_a) and decelerating (x_d) distances, i.e.,

$$x_a + x_d = 20 \text{ ft.}$$

Hence, $\frac{v^2}{2(5)} + \frac{v^2}{2(4)} = 20$ ft.

Consequently, the highest speedreached was v = 9.4 ft/s. In addition,

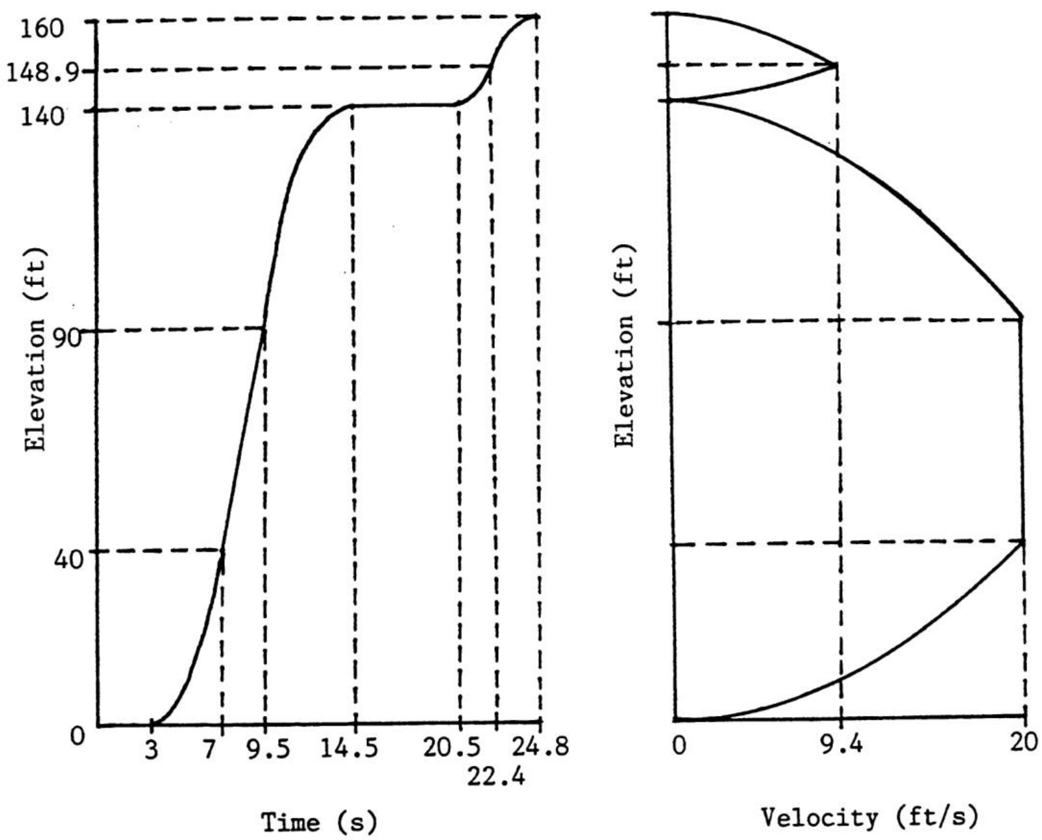
Acceleration distance ≃ 8.9 ft.

Deceleration distance ≃ 11.1 ft.

Acceleration time ≃ 1.9 s.

Deceleration time ≃ 2.4 s.

The required diagrams are drawn below.



2 A car collided with a telephone pole and left 20-ft skid marks on the dry pavement. Based on the damages sustained, an engineer estimated that the speed at collision was 15 mi/h. If the roadway had a +3% grade, calculate the speed of the car at the onset of skidding.

The estimated speed at impact was 15 mi/h or 22 ft/s.

α = arctan 0.03 = 1.72°.

D_b = x cos 1.72° = 20 cos 1.72° = 19.99 ft ≃ 20 ft.

In the absence of a measured value for f, use 0.6 as an approximation since the pavement was dry. Using v = 22 ft/s and G = +0.03, apply

$$D_b = \frac{v_0^2 - v^2}{2g(f+G)} \quad (G = \tan\alpha)$$

to find v_0 = 36 ft/s ≃ 24.5 mi/h. **Answer**

3 Plot the relationship between the approach speed v and the length of the dilemma zone for the following data: $a_2 = 0.5g$, $\delta_2 = 1.0$ s, $w = 65$ ft, $L = 15$ ft, and $\tau = 4.5$ s. To help you interpret this plot, draw another diagram in which the v versus x_c and the v versus x_0 relationships are superposed.

$$a_1 = \frac{2x}{(\tau-\delta_1)^2} + \frac{2(w+L-v_0\tau)}{(\tau-\delta_1)^2}$$

the length of the dilemma zone, L_D, equals $(x_c - x_o)$. Substitution of the given data into Eqs. $x_c = v_0\delta_2 + \dfrac{v_0^2}{2a_2^*}$ $x_0 = v_0\tau - (w+L)$ yields:

$$x_c = 1.0\ v_o + \frac{v_o^2}{32.2}$$

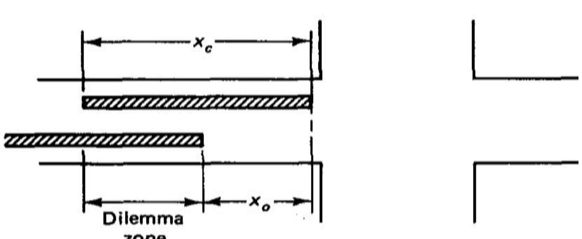
$$x_o = 4.5\ v_o - 80$$

and $$L_D = 0.03\ v_o^2 - 3.5\ v_o + 80$$

This is a quadratic equation with roots $v_o \simeq 32$ and $v_o \simeq 85$ ft/s. By setting the first derivative of L_D with respect to v_o equal to zero,

$$0.06\ v_o - 3.5 = 0$$

the critical point is found to occur at $v_o \simeq 58$ ft/s. Since the second derivative at this point is +0.06, the curve is concave upward and the critical point is a minimum. At this point the value of L_D is −22 ft. The relationship between approach speed and the length of the dilemma zone is plotted on the following page. Note that negative values of v_o are meaningless in this case; they may describe the situation in which the vehicle backs up to clear the intersection behind it! Also, negative values of L_D represent the situation illustrated by Fig. 1 in the textbook, a situation that does not present a dilemma zone problem. Thus for the data given the dilemma zone problem arises for the range of speeds



(c)

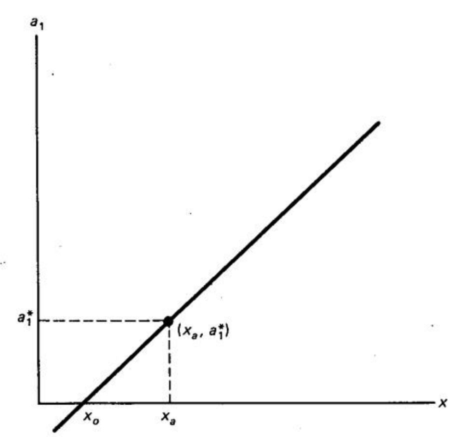


Fig. 1

$v_o < 32$ ft/s and $v_o > 85$ ft/s