. 10 1. Someone tosses a tomato straight up in the air. The height of the tomato is $s = 3 + 25t - 4.9t^2$ meters after t seconds, ignoring air resistance.

(a) Give the velocity and acceleration of the tomato.

(b) What is the average velocity of the tomato in the first 2 seconds and the (instantaneous) velocity at $t = 2$?

(c) How high does the tomato go?

(d) How long is the tomato in the air?

(e) If the tomato was tossed upward on Mars, where $g = 3.72\,\text{m/sec}^2$, what would be the formula for the height of the tomato? (As with all questions, you should explain clearly and briefly how you obtained your formula.)

Solution. For (a), we have

$$v = \frac{ds}{dt} = 25 - 9.8t\,\text{m/sec}, \qquad a = \frac{dv}{dt} = -9.8\,\text{m/sec}^2.$$

For (b), the positions at $t = 0$ and $t = 2$ are $s(0) = 3$ m and $s(2) = 33.4$ m. Thus, the average velocity is

$$v_{\text{avg}} = \frac{s(2) - s(0)}{2 - 0} = \frac{33.4 - 3}{2} = 15.2\,\text{m/sec}.$$

The instantaneous velocity is $s'(2) = 5.4\,\text{m/sec}$.

For (c), observe that the velocity of the tomato is postive, so the tomato goes up, and then the velocity decreasing until it becomes negative, when the tomatos starts falling. Thus, the maximum height of the tomato occurs for t satisfying $v(t) = 0$. So we solve $25 - 9.8t = 0$, which gives $t = 25/9.8 = 2.551$ sec. Next, $s(2.551) = 3 + 25 \cdot 2.551 - 4.9 \cdot (2.551)^2 = 34.888$ m. So the tomato reaches a maximum height of 34.888 m.

For (d), we have to find times t so that $s(t) = 0$, that is, solve $0 = 3 + 25t - 4.9t^2$. Rearranging, we have $4.9t^2 - 25t - 3 = 0$ Using the quadratic formula, we have

$$t = \frac{25 \pm \sqrt{25^2 - 4 \cdot 3 \cdot 4.9}}{9.8} = \frac{25 \pm \sqrt{625 - 58.8}}{9.8} = -0.117303040 \text{ or } 5.219343856$$

Since we are not interested in negative times, the tomato hits the ground at $t = 5.219$ sec. Since it started at $t = 0$, it is in the air for 5.219 sec.

For (e), we're changing the value of g, which only appears in the term for t^2. Since the general formula is $\frac{1}{2}gt^2$, we should change the $4.9 = \frac{1}{2}9.8$ to $1.86 = \frac{1}{2}3.72$. Thus, the new formula is

$$s(t) = 3 + 25t - 1.86t^2\,\text{m}.$$